LEARNER CENTRED CONTROL IN COMPUTER BASED TRAINING

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Summary

This research investigated some dimensions of self directed learning in Computer Based Training (CBT). The proposal was that increasing the control of the learner would result in an improvement in learning. This was investigated in two main ways. The first was to give the learner control over the sequencing of the training modules. The second was to engage the learner in a form of self assessment. The project required the design of CBT courseware to test the hypothesis. Therefore principles of CBT design were also considered. The results suggested that providing the learner with control over the training sequence led to a significant improvement in transfer performance. Involving the learner in self assessment activities led to only a marginal improvement. By recording the learners activities in the CBT it was possible to identify strategies adopted during the training phase. Further consideration was given to subjects' strategies and learning outcomes. Finally, it was suggested that further research into hypermedia could further explore the philosophy of learner centred control. This medium may also allow the examination of learning strategies in greater detail.

KEYWORDS

Computer based training

Learner centred control

Non-linear environments

Self assessment

For Maggie and Joshua.

You are at the centre of my thoughts.

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1. INTRODUCTION

The introduction chapter starts by defining training and learning. Then the topic of computer based training is introduced by first considering the technological developments that have made the medium viable for instruction. This is followed by a consideration of its inherent advantages and some possible drawbacks. Some instructional design theories are considered. The second half of the chapter considers the proposal of learner centred control. Under this remit the major topics discussed are: self directed learning, individual differences and self assessment.

1.1. COMPUTER BASED TRAINING

Computer based training (CBT) has the potential to be exploited as one of the most exciting examples of instructional media. Yet designers often fail to realise this potential. This is, in part, due to the limitations of hardware, software, and guidelines for designers of CBT (through lack of conclusive research), but is probably also due to the limitations of the designers' own cognitive set. Good CBT may owe more to the imaginative flair of the courseware designer, than it does to the laborious procedure of planning frame sequences. This observation is backed by those of Dean & Whitlock (1988) and Heines (1984). This thesis attempted to combine an imaginative and planned approach.

1.1.1. Definitions

Some ambiguity exists between what constitutes training and learning. The following working definitions are given to rectify this. The problem is one of direction. Training is the projection from the instructional medium and material to the individual, whereas learning is the individual's absorption of this projection.

1.1.1.1. Training

Training is what an individual is given, it is applied externally, coming from an external source to result in a change in performance. Three definitions given are:

a) Training is a term used to describe those processes that enable an individual to develop and improve their performance in some task oriented skill (Barker & Yeates, 1985).

b) A practical education in preparation for performance by instruction and practice (Chambers 20th Century Dictionary).

c) The systematic development of the attitude/knowledge/skill behaviour pattern required by an individual in order to perform adequately a given task or job (Anon, 1971).

1.1.1.2. Learning

Learning is internal to the individual. It is what the individual can be assumed to be doing whilst being trained: an internalisation of the training leading to the building of cognitive structures and resulting in a change in behaviour. Two definitions are:

a) Learning is a term used to describe those internal mental processes (and external activities) which an individual uses in order to increase their knowledge about some universe of discourse (Barker & Yeates, 1985).

b) Learning: to gain knowledge, skill, or ability (Chambers 20th Century Dictionary).

However the ambiguity between what is training and what is learning remains, and is acknowledged (Anon, 1971). The two terms are often used interchangeably.

1.1.1.3. Computer based training

The terms computer based training (CBT), computer assisted learning (CAL), computer assisted instruction (CAI), computer managed instruction (CMI), computer managed learning (CML), and computer assisted training (CAT) are often confused and used interchangeably. For the purposes of this research, CBT is defined as a medium for training which is solely based on the computer. This is distinguished from the other terms by the use of the computer medium to; present the instruction, present practice sessions, provide guidance, feedback performance, and record all of the learners activities. Dean and Whitlock (1988) present this definition in a clear way as shown in figure 1a.

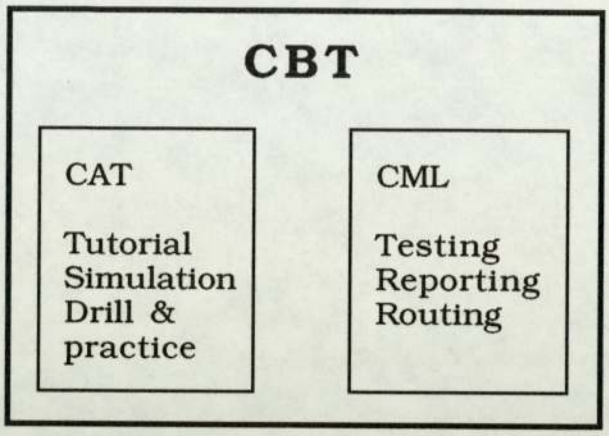


Figure 1a. Definition of CBT (taken from Dean & Whitlock, 1988)

1.1.2. Technological Developments

Rapid technological development in computing over the past four decades has seen advances on four fronts. These are; hardware, cost-performance ratio, interface, and software. The hardware has progressed from valves, through transistors, to integrated circuits. This has correspondingly led to an increase in performance and reliability accompanied by a decrease in cost. The manner in which the medium is used has also changed. Originally programming was cumbersome with off-line batch processing, this was made somewhat easier with the introduction of on-line teletype. Further progression was made with to the introduction of visual display units (VDU), and the most recent development of a graphical interface incorporating; windows, icons, menus, and pointing devices (WIMP) have made interaction even simpler. These changes in mode have been accompanied by developments in programming environments. To begin with, machine code was the only option, but this has grown to provide assembler, high level languages (such as Pascal), specialized authoring languages (such as Topclass and Pilot), and more recently to visual language authoring systems making full use of the WIMP interface (such as Coursebuilder™).

Until fairly recently, the designer of CBT packages was required either to learn a high level programming language, engage the assistance of a programmer, or struggle with inadequate authoring languages. This has meant: an initial investment of a considerable amount of time, the translation of one's ideas through a third party, or a compromise on the extent of the interactive graphics (which is one of the main advantages of the computer as an instructional medium) before CBT is realised. The advantage of the first approach is that, acting as the programmer, the user can translate their own specification into exactly what is wanted, without the compromises that may be enforced by working with a third party. The advantage of the second approach is the user does not have the lead-in time required to learn the language. The advantage of the third approach is a reasonably short lead-in time together with control over production of courseware. With the recent development of visual language authoring systems, all of the advantages of the previous approaches were incorporated, whilst minimising the disadvantages encountered within these systems.

Ironically Annett and Sleeman (1971) reported that CAI was being held up by technology rather than learning theory, whereas nearly two decades later the technology has kept its' promise and the learning theory has proved inadequate. Most notably the failure of programmed instruction has led to the realisation that learning is more complex process than originally considered in behaviourist research.

In the early 1980's the availability of low budget computers has revived an interest in machines that can teach. By the early seventies it was becoming clear that teaching was an intelligent process, and that traditional programmed learning was too inflexible. A cognitive approach to the understanding of learning was being presented. In marked contrast to programmed learning it was considered that learning should be a more interactive process, enabling learners to see the consequences of their actions, and further providing them with the means of correcting inadequate solutions. The change of emphasis was on allowing the learner greater freedom within the problem space to not only achieve the correct solution, but also to get things wrong, and put them right again.

Advances in software, in particular authoring languages, has brought CBT authoring to the non-programmer. The arrival of visual language authoring systems has made this even more of a possibility. This most recent development has brought CBT to individuals whom before had never considered this medium a possibility. This direct link between author, medium and trainee has brought numerous problems to light. The most important problems relate to the inadequacies of guidelines for design if the instructional environment. Two points are important here. The medium is different to other instructional media, therefore a straight translation of existing materials for the new medium might not be the most appropriate approach. Second, instructional design theory leaves a lot to be desired, this is given greater consideration in section 1.1.4..

1.1.3. The Instructional Medium

The advent of CBT as an instructional medium was initially met with great enthusiasm. This has slowly been replaced with a more cautious approach with the realisation that the original claims to improve learning and replace trainers were grossly exaggerated (Hooper, 1977). These failures are not all the fault of the the medium, as previously indicated.

The design of CBT is critical. Text followed by multi-choice questions may not be the most effective implementation of the medium. CBT can replace traditional instructional methods. For this new medium, new instructional design may be necessary (Parker, 1980). The transfer of classroom presentation directly onto the screen first requires validation of the transfer effects before mass implementation. Further, the design of the training should be implemented in a manner that makes best use of the medium's strengths, such as the potential for interaction, graphical animation, and simulation.

CBT can be generally defined as individualized, self-paced instruction, although the amount of user control can vary. Design is all important, but comparisons of research into CBT can be difficult. This is because studies that show that a mode of CBT is effective, may just be showing a particularly effective implementation of that mode (Mahoney & Lyday, 1984; Ashcroft, 1986). All it is possible to conclude is a good implementation works. However, there are certain intrinsic potential benefits and pitfalls considered further in sections 1.1.3.1. and 1.1.3.2.

1.1.3.1. Potential Advantages of CBT

Potential advantages of CBT are numerous, but they certainly include the following:

- learner pacing of presentation
- active participation in learning
- individualisation
- flexibility
- timeliness and availability
- immediate knowledge of results
- economic factors

(Hudson, 1982; Hobson, 1985; Guest, 1986)

The learner has control over the rate of presentation, which means that slow and fast learners, are not respectively lost or held back. This has a greater advantage over traditional classroom training by allowing to trainees proceed at their own pace. However it has been reported (Dorssett & Hulvershorn, 1983) that peer training (two trainees working together) reduces training time further without reducing performance. This is particularly noticeable when there is a mismatch between the ability of the two trainees. The majority of people in the peer training scheme also reported preferring to train in pairs, rather than alone, showing benefits to be social as well as performance related.

The trainees can also have a more active role in their own training. With other media such as lectures, books, and audio visual aids the direction of the communication is mainly one way, from the media to the trainee. With CBT not only does the medium communicate with the trainee, there is also the potential for the trainee to interact and communicate (albeit to an unintelligent program) back to the computer. The students' actions can influence what the computer displays next, and so on. Students may find it difficult or embarrassing to stop a lecture, it is certainly impossible to ask a book a question. The CBT designer is set with the challenge to make the CBT interactive. Many implementations are no more interactive than other media such as books and films, and much less interactive than some lectures.

The degree of interactivness also influences the individualisation of the training. It may be very adaptive to the levels of skills, abilities and needs of the individual trainee, or present every trainee with exactly the same material, in exactly the same sequence regardless of the specific needs of the trainee. Further the medium can ensure that mastery of one topic is complete before the trainee is allowed to progress to the next (Patrick et al, 1986), ensuring that trainees do not get out of their depth. This may also help to prevent any of the trainees getting to a point where they are unable to proceed further.

CBT is flexible along two major dimensions. The hardware may be used for the training of individuals and as a tool for many other tasks (such as word processing, drawing, accounting, storage of records etc.). The software may be adapted for training many different tasks. This may include minor alterations when one of the tasks changes slightly, or when an aspect of the training is found to impair transfer. The inherent flexibility of the computing medium is that it can be adapted for many different tasks.

As a training medium the computer has the advantages associated with more personal training media (such as printed materials) including those of timeliness, availability, localisation and even portability (particularly with the increasing power and sophistication accompanying lap top micro computers). These developments make CBT an even more attractive medium. Trainees are able to undertake training at a time and in a place that is convenient to them. From the point of view of the trainer, CBT, can have distinct advantages over the use of actual equipment in a risk versus potential equation (Guest, 1986). The risk element relates to the feasibility of training on the real operational equipment. This may not be practical due to: timescales, expense, lack of feedback and risk acceptability. CBT has many inherent potential benefits, including: allowing the learner active participation in learning, pacing of instruction, immediate knowledge of results and economic factors. The actual equipment may not be feasible for training for reasons similar to those given for the use of simulators by Whiteside (1983) such as: cheaper and safer than the real equipment, the possibility to create unusual or rare sequence of events in order to train procedures and the ability to measure competence. Related to the individualised and interactive aspects of CBT is the role and nature of feedback in training. There is the potential for feedback to be very close in proximity to the trainees' actions. The short time loop between action and knowledge of results can be exploited to the full through interactive training simulations.

Economic factors are also an important consideration in the choice of instructional medium. A variety of factors may lead to CBT fulfilling this criteria for selection. These include the issues of flexibility of the hardware and software already raised. Also the courseware is reusable. CBT may reduce the time it takes the trainee to become proficient, and it can make expert knowledge more widely available (Lewis & Mace, 1988). CBT can be used in more than one place at the same time. This could also be true for lectures if closed circuit television was used, but then interactivity is lost. Once the capital equipment and authoring software is purchased, the ongoing costs are limited to the authors' time. The author can remain remote from the end users. O'Neil & Paris (1981) cite the advantages of CBT as those of predominately reducing cost and increasing effectiveness. However, despite all of these advantages, there are also some potential disadvantages which are covered in the next section.

1.1.3.2. Potential Disadvantages of CBT

Some of the problems related to the use of machines in training humans are as follows:

- Dehumanisation of instruction
- Replacement of trainers
- Poor Transfer
- Problems of Evaluation

There is a fear that CBT will replace the human trainer, and that it is a dehumanising form of instruction (Hudson, 1982). Both of these fears may be misplaced. CBT is just another instructional medium (which may be used in conjunction with other media, Berman, 1986). It is not a replacement for trainers, although it is likely to require the trainer to learn new skills (Hudson, 1982). Results from trainees' interactions using CBT may alert trainers to individuals requiring help and intervention. Therefore the use of CBT leaves trainers free to design courses, provide counselling and feedback to individual trainees. The quality and quantity of the attention to trainees may be enhanced through the adoption of CBT rather than reduced. Concerning the issue of dehumanisation, it must be asked "just how 'human' are other instructional methods?" As mentioned in the previous section, CBT has the potential to offer a more individualised form of instruction than most other media. It can work at the pace of the trainee, and can offer help only where it is needed. Fast learners are not slowed down by slow learners, and visa versa. Trainees can get extra help or practice if they find a particular area difficult to grasp. The person's progress may be recorded so the computer always knows how fast the instruction is progressing. Attempts have been made to counter the dehumanisation criticism, e.g. the computer is able to refer to the person by name. However, more often than not, trainees find this rather patronising and annoying.

Poor transfer can often be attributed to poor implementation of the training medium, and the lack of skill of people involved in design (Ashcroft, 1986). New instructional media may require new instructional methods to reach their full potential (Andrews, 1983). The transfer of classroom lectures to screen-based instruction in a drill and practice format is unlikely yield this potential. The indication is that correctly designed CBT will transfer positively to the real operational environment (Crawford & Crawford, 1978).

One major issue in the prospective implementation of CBT is how to evaluate its effectiveness. Cost, training time, and trainee performance are all important considerations (Carey, 1986). There are indications that CBT can be effective in meeting these factors, for example Hobson

(1985) quotes comparisons with classroom instruction where completion times were 31% quicker, achievement scores showed 96% versus 90% mastery and attitudes were more positive towards the CBT medium.

In the example given by Hobson, development time for CBT far exceeded that for traditional instruction, and this is likely to be usual. The development times were 150 hours courseware design for every one hour instruction for CBT. Traditional classroom instruction typically required 17 hours preparation for every hour of instruction. So clearly CBT comes with a price tag, but as mentioned in the previous section it can be reused, duplicated and disseminated.

The extended development time quoted may be, in part, due to CBT being a relatively new instructional medium, and improvements in authoring languages could reduce this. However, once the courseware is developed, no more work is required except for modifications, if the content of the course changes. At present, courseware requires considerable preparation and thought prior to implementation, as every possible eventuality needs to be planned for.

The preparation will include deciding upon the content of CBT. This may be derived from an analysis of the task to be trained (i.e. assessing the knowledge structure of incoming students compared to experts in order to design content, Thomason, 1981). Decisions on how this content will be presented will be influenced by instructional design theory.

Problems with choosing methods for evaluating instructional media are not just restricted to CBT, but the new technology seems to have highlighted the problem. There is a need for evaluations of effectiveness to be more rigid (Miller, 1982). Given CBT's potential for collecting all manner of data from the trainee, this dilemma is particularly marked.

In addition, the medium may just be judged inappropriate for a particular application. Therefore other instructional media will need to be considered, and their 'pro's and con's' weighed up against the CBT alternative.

1.1.3.3. Other Instructional Media

There are a multitude of potential instructional media, of which CBT is only one. Others include: instruction manuals, print, drawings, photographs, slides, audio tapes, video tapes, lectures, television, films, tutorials, group seminars, demonstrations and simulations (Patrick et al, 1986). Each has its own potential advantages and disadvantages as summarised by Patrick et al, but CBT can be seen to include a number of the advantages over other instructional media. For example it is possible to demonstrate and simulate via CBT. Voice and sound can also be included, and laser disc can enable high quality colour graphics. Movement and interaction are also part of the intrinsic qualities of CBT. These features make a strong case for CBT. However CBT will not always be appropriate and other considerations such as cost, bulk, robustness, and personal preference can count against it.

1.1.4. Instructional Design Theory

Effective instructional design should be influenced by an extensive understanding of the processes involved in the acquisition of skills and knowledge. Unfortunately this is not the case, as Norman (1980) observed, this key issue (learning) still largely remains elusive. Learning appears to involve:

> "continual exposure to the topic, probably accompanied by several bouts of restructuring of the underlying mental representations, reconceptualisations of the concepts, plus many hours of accumulation of large quantities of facts."
> (Norman, 1980)

Learning is a complicated and time consuming process, and it is difficult to study. However, there is an extensive range of instructional theories for the designer to choose from. They each tackle the problem in a different way. In a review of theories, Stammers & Morrisroe (1985) showed that they differ on several dimensions. First there is the concern for creating a mental set, so that incoming information can be absorbed in the right context. Next is the division and subdivision of the material, either to be built up or filled in by the learner, depending if the theoretical perspective advocated, e.g., a top down , bottom up, or filling in mode. Another dimension was to consider the content of the material to be learnt, and at which cognitive level it applied. A final dimension covers the level of individualism in the learning process, with material structured to best suit the individual's own particular cognitive style. Whether this is done intelligently by the system, is preset on the basis of pretesting, or is structured by the individual themselves is another issue. Stammers & Morrisroe (1985) outlined a number of theories, e.g., assimilation to schema; elaboration; web learning; levels of learning; and multi-level. These are considered briefly.

The assimilation to schema theory (Stammers & Morrisroe, 1985 cite Ausubel, 1969) suggests that before effective learning can occur, it is first necessary for the trainee to possess the correct schema through which to receive the incoming information. Once this is in place, the trainee is then able to build on existing knowledge in the right context. This theory can be linked to Niesser's (1976) notion of the schema as an interpreting mechanism that makes sense of incoming information. An incorrect contextual set may increase the possibility of misinterpretation, and therefore reduce the effectiveness of learning.

The elaboration theory suggests that instruction should begin with the general outline of the topics to be covered. This, in effect, orientates the trainee as to what to expect in the instruction to follow. The elaboration then given divides and subdivides the material into parts to yield more detail until the desired level of learning is reached. Reigeluth (1983) described elaboration theory using the 'zoom lens' analogy. the learner starts with the wider angle view (major parts and major relationships), and then zooms in one level on a given part to see more about each of the major subparts. Having studied those subparts and their interrelationships the learner can them zoom out to the wide angle view to review the subparts within the whole picture. Reigeluth suggested that there may be a restriction placed on learners that prevents them from viewing anything that they have not viewed from a higher level.

The web learning theory (Stammers & Morrisroe, 1985 cite Norman, 1983) suggests that instruction takes the form of an initial outline or supporting web structure. This is then progressively built up as more and more details are filled in as learners build up appropriate cognitive structures. The web learning approach lends itself to the creation of hypertext networks, discussed further in section 1.2.1.

The levels of learning theory suggests that instruction should proceed from the lower levels of learning up to the higher levels. Movement up to the next level only occurs when understanding is complete at each level. Stammers & Morrisroe, 1985 cite Gagné (1977) who attempted to classify levels of learning, increasing in complexity at each level. The levels were:

Signal learning
Stimulus-Response
Chaining
Verbal association
Discrimination learning
Concept learning
Rule learning
and Problem Solving.

Gagné further proposed four stages of a learning sequence: apprehension, acquisition, storage and retrieval. A more recent levels of learning theory has been proposed by Merrill (1983) called 'component display theory'. In this theory Merrill classifies learning objectives along two dimensions, type of content and level of performance. Under content his levels are: fact, concept, procedure and principle. His stages, or levels of performance, are: remember, use and find.

The multi-level theory suggests that learning occurs at many levels, and this will depend upon the trainee's own individual style. Some individuals will be able to tolerate uncertainty in learning and others will not. This tolerance may make certain trainees more suited to top-down instruction and other more suited to bottom-up instruction. Pask (1976) suggested two broad ways in which learners may differ in their approach to learning. He called these 'holist' and 'serialist' learners. His proposal suggests that individual differences in learning style are worthy of further investigation.

The multi-level theory is different from the first four in its attention to the individual at the micro level. The other theories operate at the macro level in attempting to provide an overall instructional design theory.

Clearly there are many factors that effect the transfer of instruction, but these will certainly include the following:

- practice and repetition
- feedback and knowledge of results
- task difficulty
- psychological orientation
- intelligence
- motivation
- experience

(Stammers, 1985, b; Mahoney & Lyday, 1984; Sklaver, 1986; Morris & Rouse, 1985; Pintrich, Cross, Kozma & McKeachie, 1986; Keller, 1983)

The failure of theorists to produce a unified, fully validated, instructional theory can be understood more clearly when the number of possible variables are identified. This is because such a theory would have to allow for such variables as e.g.: factors contributing to instruction and learning, the task to be learnt and individual characteristics of the learner. For example, four dimensions of motivation have been identified (Keller, 1983) which are:

- Interest
- Relevance
- Expectancy
- Satisfaction

For each of the dimensions, Keller puts forward strategies to be incorporated in instructional design. These can be regarded as a cookbook formula rather than relying upon any theoretical underpinning. The interest dimension refers to the arousal of the learners' curiosity, and the extent to which this is sustained over time. Relevance is the degree to which the learners perceive the instruction to help achieve their goals. The expectancy dimension relates to the learners' perception of their likelihood of success and the extent to which this is seen to be under their control. Satisfaction is regarded as the learners' intrinsic motivations and their reactions to extrinsic rewards. The motivational aspect of learning is regarded as one of the most important learner characteristics, which together with intelligence, influences the success of a programme (Pintrich, Cross, Kozma & McKeachie, 1986).

It has been suggested that the more entertaining the presentation, the less effective its application to training (Thomas & Thomas, 1984). They based this assertion on the findings from a study for video-based training. However, it is probably just as likely that their study referred to poor implementation, i.e. it fulfilled the interest criteria, but not the other three (relevance, expectancy and satisfaction), and therefore was not taken seriously. This highlights another problem that instructional theorists face. They are not only required to overcome all factors relating to learning, task type, and learner characteristics, but also to take into account the courseware designers' implementation of the theorists' guidelines.

It was noted in a recent survey of designers of CBT that the design process was the most difficult, and yet most important, part of the procedure (Learning Technology Unit, 1988). Task analysis was one of the tools that designers use for the structuring of data about the task. This technique also lends itself as a natural structure for the training modules, and has been put forward by Shepherd (1985) as a tool for facilitating training design. Shepherd claimed that it not only serves to clarify the content of what should be trained, but it also clarifies the training objectives. This particular technique was therefore adopted in this investigation. The use of task analysis led to the adoption of a hybrid approach to instructional design. This incorporated elements of elaboration, a webbed network, assimilation and a multi-level approach. The modular structure of the training enabled each section to be introduced as a part of the whole task, and therefore a context remained. Each module focused in on a particular aspect to be trained, and then the focus widened before the next topic was introduced. This is explained in greater detail in section 3.2.2.

1.2. LEARNER CENTRED CONTROL

In a report examining CAL research (Annett, 1976), the diversity of approaches in learning was contrasted. An idiographic approach (examining individuality in learning) was placed at one end and a nomothetic approach (looking for commonality and deriving rules) at the other. The problems faced by both approaches is considerable, as Annett summarised:

> "The nomothetic approach has to face the almost insurmountable problem of the large number of variables operating in particular cases. The critical problem for an idiographic approach is that of conceptualising learning as a process and analysing cognitive structures which are engaged in learning."

Research in both streams continues, and the problems are far from being solved. Inroads are being made however. This is translated into research either in AI (nomothetic) or Hypertext (idiographic) at the extreme ends of the spectrum. The proponents of Hypertext (or hypermedia as defined in section 1.2.2.) dislike the AI perspective because it suggests to them that the machine should be in control rather than the human (Nelson, 1989). The hypermedia approach does allow research to be conducted into individual differences, which itself, ironically, may provide the impetus for finding commonality and pursuing the AI route. Thus the two approaches are not as opposing as might first appear, and both can complement to each other. Indeed a practical solution might involve a combination of the two, the hypermedia interface allowing the learner to explore and make his, or her, own links whilst an AI tutor provides help where needed. The latter could limit the choices (intelligently) if the trainee becomes overwhelmed by the environment. The degree of control the trainee has could be increased as competence increases, with natural transition occurring without the trainee overtly realising it. The investigation to be reported here was concerned with both approaches. First consideration was given to individual differences, but a search for commonality was pursued.

If it is to be accepted that there is a cognitive basis for learning, then it is not only the interaction between the human and the machine in CBT that is important. The quality of interaction will also determine the success of the particular implementation. Figure 1b shows the range of type in interaction that is typically found in CBT.

LOW	MEDIUM	HIGH
page turning	response to stimuli	interactive simulation

Figure 1b. A range of interactions within CBT.

The mode of the training could also influence its effectiveness, be it drill-and-practice, problem solving, simulation or tutorial. In a review of the research, Edwards, Norton, Taylor, Weiss & Dusseldorp (1975) found CAI to be more effective than traditional (classroom) forms of instruction, but could not conclude that one particular mode of CAI was better than any other. The literature could be criticised for not providing direct comparisons of this sort. The observation could also reflect that the particular mode was task dependent, and implementation dependent.

It could however, be reasonably argued that encouraging learners to have greater control over their own learning would make CBT even more effective. This is the basic premise of the research to be reported here. It is approached in two ways. The first is to encourage the learner to be self-directive, and the second is to encourage the learner to self-assess. Encouraging the learner to take control over direction and assessment in training are both forms of self empowerment. This ideally should lead the learner to develop the skills required for each of these activities. Some success has been attributed to training activities that employ this type of process, (Artingstall, 1982), although it was reported that initially some participants disliked the self-directed learning process.

1.2.1. Self Directed Learning

The computer as an instructional medium is held to have benefits such as; learner pacing of instruction, the interactive quality of the medium, immediate feedback, and the individualisation of the learning environment (Hudson, 1982; Hobson, 1985; Guest, 1986). It is the interactive and individualised nature of computer based training (CBT) that sets it apart from most other instructional media. The effectiveness of any CBT package is totally dependent upon its design (Mahoney & Lyday, 1984; Ashcroft, 1986). This has led to theories of instructional design, and the development of design procedures for CBT. However, as considered in section 1.1.4. instructional design theories largely remain to be tested empirically, and none of the theories proposed to date have proved to be universally adequate.

One solution to this problem is to allow the learner to decide how the information to be learnt is presented. An individualised approach has been called Self Directed Learning (SDL) which is defined as:

> "a process of learning...such...that each person learning will be able to identify and have easy access to appropriate resources, which are so organised that they lead towards chosen goals along whatever path the learner prefers." (McCafferty, 1981)

The self-directed approach considers learning to be a personal, individual act, and advocates that the learner should take the responsibility for learning. Decisions such as; determining goals, deciding on materials, structuring, grouping and allocating tasks, as well as evaluation, all come under the learner's remit for management in learner centred methodologies (Dickinson, 1981, a). Dimensions of self direction are; aims, method, pace, place, materials, monitoring and assessment. Each of these dimensions emphasise the autonomy of the learner, as Dickinson argues, autonomy represents maximum self-direction on a scale ranging from directed to autonomous learning.

Giving the learners autonomy assumes that they want it and that they are able to cope with it. This follows from the assumption that individuals are self motivated.

In terms of McGregor's proposed theory X and theory Y (as cited by Luthans, 1985) theory X proposes that individuals are inherently lazy and only extrinsically motivated, whereas theory Y proposes that individuals: exercise self-direction, find rewards in achievement, seek responsibility, welcome mental and physical effort. This theory suggests that these factors for theory Y hold only when individuals are in the environment that allows them to flourish, such as autonomy. Putting individuals in a highly directive environment, and thereby accepting theory X, could lead them to behave in the opposite manner to theory Y, and therefore becoming a self-fulfilling prophecy.

This suggests that placing individuals in an environment that allows then to be self directive will lead them to behave in a self-directive manner. Mager & Clarke (1963) proposed that learners may often enter the learning environment with a significant amount of relevant knowledge. Therefore allowing the learners to judge and choose what they need to add to their current knowledge to meet the training objectives would reduce both training time and boredom.

SDL shares much of the same terms as hypermedia, such as 'networks' and 'pathways'. Hypertext (Nelson, 1981) is the idea that knowledge (be it in the form of text or graphics) may be linked in many ways, providing no formal structure, allowing the individual to explore the knowledge domain at will. Norman (1988) gives a rather limiting definition, explaining the 'hyper' element as:

> "a higher-level text that comments on and expands the main text, allowing the reader the freedom to explore or ignore the material as interests dictate."

However, Norman does intimate that the lack of preconceived organization could allow thoughts to be juxtaposed at will, which is closer to Nelson's own interpretation. The hypertext approach has certain advantages over linear training. For example, courseware authors do not have to concern themselves with structuring the information in any particular order. Trainees may approach the learning environment with a wealth of previous experience which can enable them to be directive in their own learning. The existence of learning skills and strategies may transfer to the new environment (Perry & Downs, 1985). If learners are able to choose how the information and instruction is presented to them, in the manner that best suits their own style of learning, then the whole process may be more efficient. In addition, this phenomenon should speed up the process of authoring course materials (Hammond & Allinson, 1989). This idea is challenged by Norman however, who claims that hypertext will create more, not less, work for the author. He argues that the author will still be required to structure the material for the reader, but in many different ways. To do this poorly would put a great burden on the reader, who may be unable to cope. To some extent this prediction has come true, and issues such as cognitive overhead and navigational problems are discussed in section 5.3. Hammond (1989) suggested that a hypertext environment contains three main dimensions that could be manipulated, as illustrated in Figure 1c.

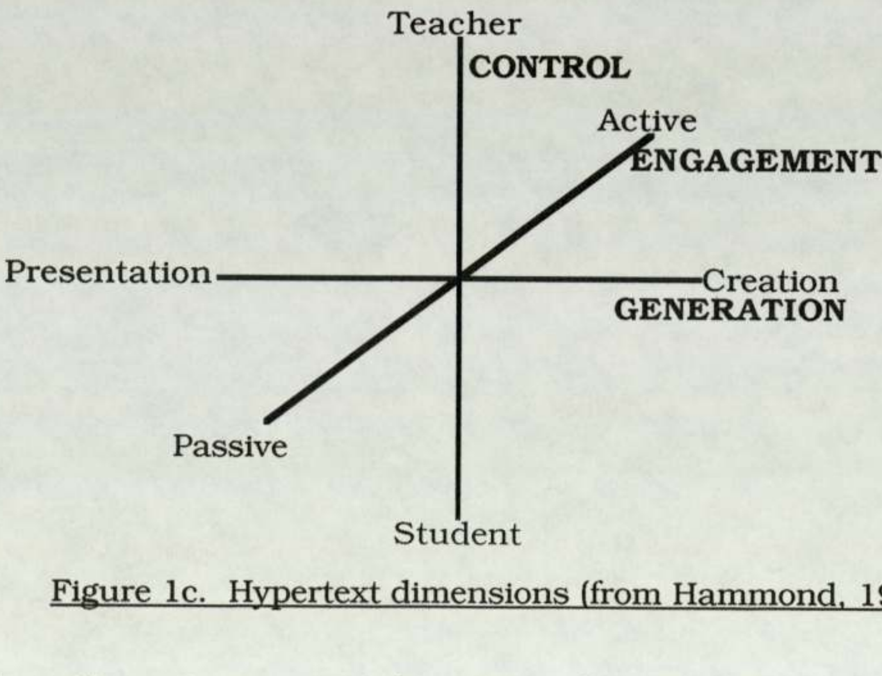


Figure 1c. Hypertext dimensions (from Hammond, 1989).

The three dimensions proposed are; control, engagement and generation. Each of the dimensions has the potential to be either teacher (i.e. courseware designer) or student controlled. At one extreme training could be presented to the students in a passive manner, involving them in little more than page turning, whilst at the other the students could have full control over what they choose to see and are actively involved in creating something new out of what already exists. This is the futuristic ideal of hypertext. As Nelson (1974) wrote:

> "the structure of ideas is not sequential. They tie in together whichway...In an important sense there are no subjects at all; there is only all knowledge, since the cross-connections among the myriad topics of this world simply cannot be divided up neatly."

Nelson sees each user in the hypertext network as an author, structuring and changing the material in their own individual way. This is rather more than the current implementations allow. They consist of electronic footnotes and preset links, which the user is unable to edit for their own purposes. For example in such systems as Guide™, although the user can explore the document in a non-linear way, this exploration is down predetermined pathways. The gulf between such systems and 'Project Xanadu' (Nelson, 1981) is the mode of user interaction. In the systems such Guide™ it is intended that there is one author and many readers. Whilst in the project that Nelson inspired it is intended that every reader has the opportunity to become an author and freely edit the materials for their own purpose.

One further dimension that is worthy of consideration is the notion of 'self perception' and 'attribution'. If individuals are actively involved in deciding what is to be learnt, and in what order it is to be learnt, they are perhaps more likely to interpret personal (internal) attributes (such as quality of these decisions) as determining their success. This is likely to lead them to behave differently in the learning task to individuals who perceive the situation as involving an external locus of control. The latter could arise if the computer is seen as responsible for deciding which training module is presented next. Luthans (1985) reports studies suggesting an internal locus of control leads to better performance. This may be due to more effort being exerted when the locus is perceived internally. The individuals may internalise the outcomes and goals as being their own. This increased commitment to the goals leads to increased motivation to see that they are realised. In addition, if the individuals perceive that they can have some influence on their surroundings, they are more likely to engage in activities that are able to achieve this (Shackleton & Fletcher, 1984). On the other hand, individuals who perceive the locus of control as external are less likely to be as successful. They are unlikely to attempt to influence their environment. They remain more passive and are less likely to internalise the goals. Their motivation and commitments are likely to be less than that shown by internal locus of control individuals. Linked to the notion of control is 'learned helplessness' (Rachlin, 1976) which suggests that failure can lead individuals to 'give up', or become passive recipients. Norman (1988) suggests calling this phenomenon 'taught helplessness' referring to the teaching (or training) failing to impart the information in one stage which then hinders further stages.

1.2.2. Individual Differences

As previously noted by Mager & Clarke (1969), allowing the learner to control the sequence of instruction has potential benefits over presequenced instruction. This most likely involves creating the type of learning environment that:

- allows for different levels of prior knowledge
- encourages exploration
- enables subjects to see a sub-task as part of the whole task
- allows subjects to adapt material to their own learning style.

Individuals approach the training medium with differing levels of ability, experience and insight, and therefore have different requirements. These are not catered for by presequencing instruction. It is felt preferable to give control to the individuals who can go into as much depth as they feel necessary to enable them to perform the task confidently. In addition, the individuals' level of motivation may be affected by their attitude towards the learning material, i.e. the degree to which they feel the training is helping them towards their goal of being able to perform the task. This goal may be hindered by what is regarded as irrelevant information. This can arise if the learner has already gained some knowledge of the topic from the presequenced condition. Subjects in the learner sequenced condition are however less likely to experience goal prevention, than those subjects who have control over the material.

The learner sequenced condition should also encourage exploration, to the extent that there was no imposed sequence for accessing the modular format of instruction and practice phases (Wendel & Frese, 1987). In addition the training should be task-orientated and subjects should select a change in modules via an overview screen. The use of an overview was further supported by evidence from Fitzgibbon & Patrick (1987) who demonstrated that this helps facilitate learning by increasing the emphasis of the sub-task as part of a whole, thereby maintaining the goal direction of the training.

Learning style was also considered to be an important independent variable in the learner sequenced condition. As discussed earlier, allowing the learner to control the sequence of instruction provides great potential for examining individual differences in learning. Schmeck (1985) defines learning style as a predisposition to display a particular kind of behaviour, and suggests that it is probably a translation of personality and cognitive style characteristics. Brooks, Simutis and O'Neil (1985) describe four general categories of individual differences that are related to learning strategies, namely; abilities, cognitive style, prior knowledge and motivation.

Abilities are considered to refer to the individuals' capacity to process information on a variety of dimensions. These have been categorised for the purposes of assessment into specific types of ability, for example; numerical, verbal, diagrammatic, spatial and mechanical reasoning. Paper based tests have evolved for testing individuals' abilities against normed groups. Cognitive styles however differ in that they are not measured on the same types of scale, they are considered to be bipolar rather than unipolar (Messick, 1976). Several cognitive styles in learning have been postulated, (e.g review by Robertson 1982). Pask (1976) identified the difference between a 'serialist', (a step by step approach in a linear fashion, increasing understanding by small increments), and a 'holist', (a more global approach, involving testing assumptions of the overall structure of the task). The dimension of field dependence (Witkin, Oltman, Raskin & Karp, 1971) in cognitive style was considered to be particularly relevant to measure learners in this study. This was because of the claim that it measures analytical functioning. Whilst the form of measure (called the Embedded Figures Test) is essentially based in the detection of simple figures in complex ones, this mode of functioning is supposed to manifest itself in all of an individuals' cognitive functioning. Given that the learner's task, i.e. to sequence the instruction, is also analytical then the bipolar dimension of field dependence could give some indication of which mode the learner is likely to engage in. The level of prior knowledge held by an individual, as previously mentioned, may also determine their behaviour and the depth they need to go into to understand the task. Finally, the individuals' attitude towards the learning situation may affect their behaviour. This will probably include their like or dislike of both CBT and non-linear environments.

1.2.3. Self Assessment

A common criticism of computer based training (CBT) as a viable training tool is its development time. Estimates of 170 hours development for 1 hour instruction are not unusual. It is therefore an attractive proposition to increase the effectiveness of the training with little extra effort and cost. This is the basic premise for investigating the use of self assessment (SA) in CBT.

According to Boud (1986) the defining characteristics of self assessment for learners are:

a) identifying standards and/or criteria to apply to their work, and

b) making judgments about the extent to which they have met these criteria and standards.

Most of the literature concerning SA refers to its use in the educational context, rather than training, and goes back as early as the 1930's (i.e. Boud cites Sumner, 1932, who suggested that there was a tendency for overrating). Interest increased through the 1970's and there has become a growing awareness of the educational value of self assessment, including the related work on student contracts. The value of self assessment is that it requires learners to think critically about what they are learning. The process intrinsically encourages learners to monitor their progress, and judge aspects of their own learning. This emphasises one important aspect of SA, that learners should accept responsibility for their own learning and development. Through assessing their own performance they become more independent and more able to exercise their own critical judgment. The SA process therefore has three main potential benefits; it encourages learners to be more autonomous, develops their judgmental skills, and improves their learning. The possible improvements in learning may come through showing learners where their efforts would be best directed, and assisting them in deciding that they have learnt as much as is necessary on a given topic.

Boud and Falchikov (1988) criticised many self assessment studies that do not involve the learner in the selection of criteria, and instead require them to rate their performance on a predetermined scale. However Boud (1986) realised that it may not be possible to involve the learner in the selection of the criteria when the material to be learnt is new. However, the learner may still see the applicability of the predetermined criteria, even at an introductory level. Boud (1989, private communication) also could not see how the criteria could be learner determined in stand-alone CBT.

One method of SA is the practice of involving the trainee in assessing their confidence with the correctness of their response to a particular question. This is to be distinguished from self monitoring, in which the trainees' keep a cumulative record of their correct and incorrect responses. A review by Stammers (1985, b) considered the implications of SA in training. He suggested that SA could add to the training environment in three ways.

Firstly SA could provide greater involvement in the training process, increasing the degree of interaction and making the role of the trainee less passive. Secondly it could increase the trainees' awareness of their current level of knowledge and competence with the task. This introspective assessment of knowledge may make trainees more aware of the shortcomings in their skills, and make them more directive in their own learning. Thirdly, SA may increase trainees attention towards the outcome of their response related to the correct response. It is suggested that this assessment of knowledge and subsequent increased attention leads to a deeper level of cognitive activity, which is more likely to result in a change in learning behaviour. This change may pass on to improve the transfer task performance.

Hunt (1982) in studies based upon paired associate learning, suggested that SA can enhance the learning process by providing a more rapid acquisition of material. The present investigation set out to evaluate the use of SA in a simulated industrial training task. The task required learning how to run a 'process control' simulator. A SA question was presented to trainees after their response to a question or performance of a task, but before the feedback was given. This sequence of events produced the best performance in the study by Hunt.

1.3. HYPOTHESES

This investigation examined several factors relating to learner centred control in computer based training. From the literature it was suggested that factors relating to self empowerment, autonomy, and an internal locus of control should improve the learner's performance in both the learning environment and the transfer task. Thus the hypothesis was essentially as follows. Allowing the learner more control in CBT will result in improvements in learning and transfer performance. This translates more specifically into the following hypotheses:

a) Providing the learner with control over the sequence of training modules will result in better training and transfer performance.

b) Learners will sequence training modules in a manner that is congruent with their own cognitive style.

c) Self assessment will result in improved training and transfer performance.

With these hypotheses in mind the following experimental investigation was conducted.

2. DEVELOPMENT OF COURSEWARE

The development chapter explains the overall procedure adopted for CBT development. It then provides greater detail about the task that the training was based upon, and how it was analysed prior to the development of courseware modules. The CBT authoring environment and principles for design are considered. Finally the individual modules are described, and the procedure for debugging given.

2.1. STAGES OF CBT DEVELOPMENT

The development of the CBT courseware used in this research consisted of four distinct stages. Firstly, the task to be trained was chosen and analysed. Secondly the training modules were classified. Thirdly the modules were produced as stand alone training via an authoring system. Finally the course was piloted and amended before the experiment began.

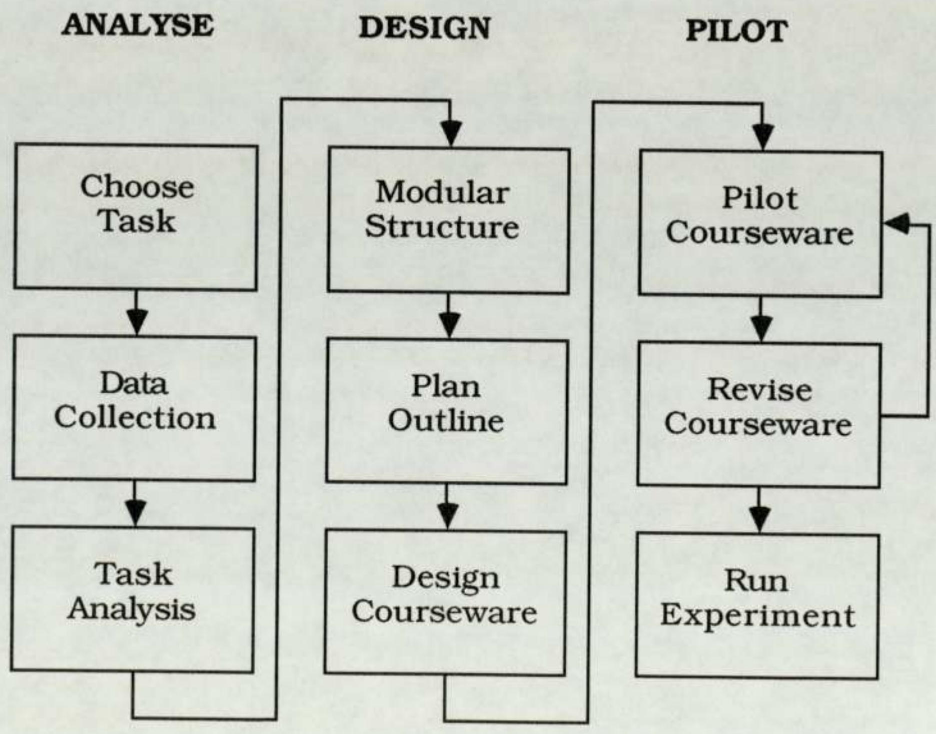


Figure 2. Stages of CBT development.

Figure 2 shows the sequence of events in the construction of the experimental courseware for the planned investigation.

2.2. THE TASK

The task that was used in this investigation was primarily used to judge effectiveness of the training, rather than fulfilling any other function. Despite its laboratory nature it was held by the experimenter to contain elements that are applicable to the learning of 'real' tasks.

2.2.1. Choice of Task

The choice of task for the investigation of learner centred control was not trivial. Certain requirements had to be met. The task had to be sufficiently complex to necessitate training, and yet had to be simple enough to be trained within a relatively short time period. Secondly the task had to be unknown to the subjects, so that no one individual had an advantage that might bias the results. The final choice of task that fulfilled these criteria was an abstracted version of a process control task that had been developed for previous research (Stanton, Carey, Taylor & Stammers, 1987). This task was familiar to the experimenter, and could be adapted for this investigation.

2.2.2. Process Control Task

The subject's workstation consisted of a monitor and keyboard. Their task was to maximize the quality of the 'output' from the 'chemical plant' by keeping impurities to an absolute minimum. In order to operate the system to achieve their goal, subjects had to first understand the screen layout and the keyboard functions. The screen layout could be broken down into five sections (as shown in figure 3). At the top of the screen was the alarm panel which would highlight any of the process variables should a preset 'alarm' limit be exceeded. In the middle of the screen was a representation of the process plant in the form of a hierarchical diagram, showing the 'output' at the top and the 27 process variables at the bottom. There were also nine middle and three top level process monitors in between. At the bottom left of the screen was an indicator of the last 'page' that the subject selected, where 'page' refers to a selected monitor or process variable.

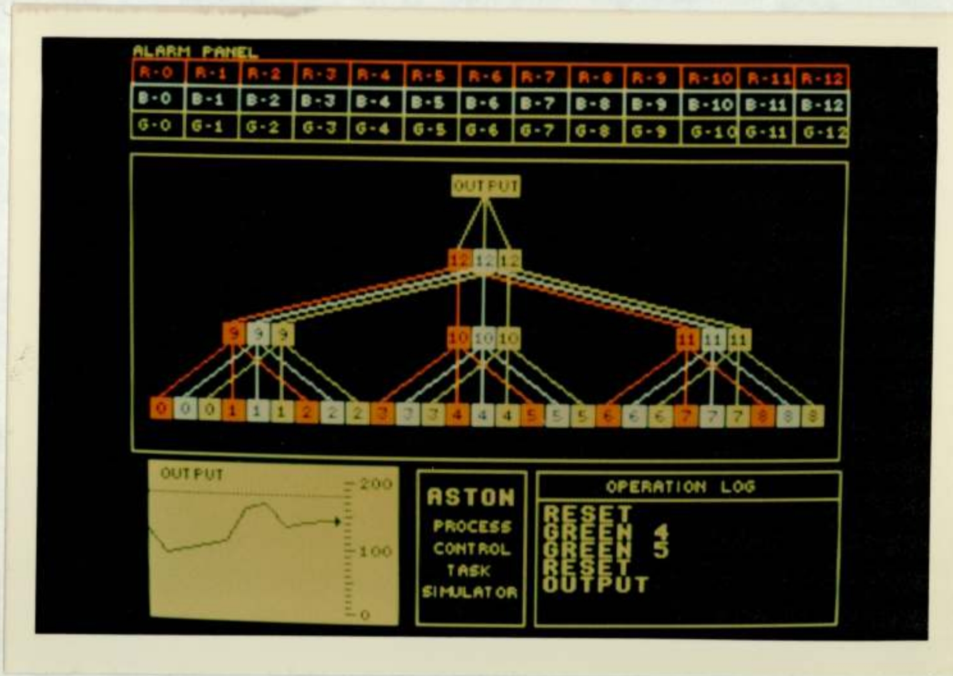


Figure 3. Screen layout.

The 'page' was presented in the form of a trend display that was updated every four seconds. The bottom centre of the screen contained a continuous read-out of the quality of overall output of the plant in the form of a moving pointer against a scale. The closer the pointer was to zero, the fewer impurities there were present, and therefore greater quality of plant output was achieved. At the bottom right hand side of the screen was the 'Operation Log'. This showed the subjects' last five trend selections (e.g. 'Red 5') in a scrolling window.

The hierarchical representation of the process plant was central to the task. It provided the subjects with a model of the process,and enabled them to see the connections between monitors and the process variables feeding into them. The principle within the representation was that any deviations in the process variables on the bottom row would feed into the mid-level monitors directly above them. Deviations were considered as movements within the variables away from their target of one hundred. The connections between variables and monitors were made explicit by the lines connecting them. The mid-level monitors subsequently fed the aggregate of the deviations they received into the top-level monitors, and the largest deviation was fed into the final monitor labelled 'output'. Only the final output was displayed continuously, all other variables had to be selected for display. Therefore if the subjects saw the 'output' rise it was possible for them to track down the deviating process variable by a process of elimination. This was intended to represent the monitoring, decision making, and searching that exists within the real task of process control.

The use of colour in the hierarchical representation was to make the discrimination between different processes clear. For instance, process variables 'Red 0, 1, and 2' fed any deviations into mid-level monitor 'Red 9'. Whilst mid-level monitors 'Red 9, 10, and 11' fed the sum received into top-level monitor 'Red 12'.

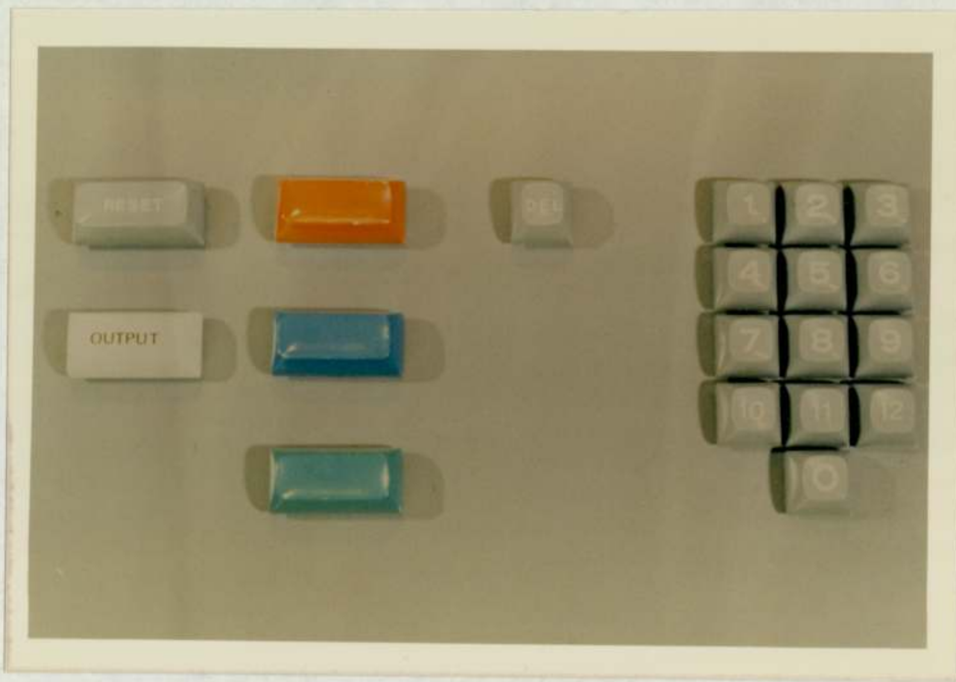


Figure 4. Keyboard layout.

The keyboard (as shown in figure 4) was the means by which the subject communicated with the screen representation of the chemical manufacturing plant. To access a process variable, or a monitor, or 'acknowledge' an alarm on the panel, the subject had to first press the correct 'colour' key, followed by the 'number' key. Any mistakes in pressing the colour key could be cancelled by the 'delete' (DEL) key. To 'reset' a variable that had gone off target the subject had to press the 'RESET' key once the correct process variable had been selected as a 'page'. It was not possible to reset a process monitor.

The main goal of the task was to keep the 'Output' pointer (bottom centre of the screen) as close to zero as possible indicating that there were no impurities, and therefore a high quality of the output process had been achieved.

The subjects were therefore able to get information regarding the state of the plant without interacting with it. However if they required further information to enable them to discover which one (or more) of the possible 27 variables could be causing the impurities in the output and reset it, interaction was required. All communication through the keyboard was recorded. By monitoring the state of the process at whatever level the subject decided, they would eventually discover that one (or more) variable(s) was the cause of the deviation, and would then have to rectify the situation. By a process of elimination of working through the hierarchy the subjects should have been able to find the faulty variable and reset it. If the alarm level was reached on any variable, then the relevant indicator in the alarm panel was illuminated and an audible alarm was sounded. The audible alarm was switched off by accessing the correct variable, and the panel indication was removed by resetting the variable. If the alarm was ignored then eventually all the process variables would have entered the alarm state. Whenever the operator keyed in a request for a page, the current value of the relevant variable was recorded. This information provided the basis of the subjects' performance evaluation.

2.2.2.1. Hardware

The process control task was presented on a colour monitor linked up to a BBC Model B microcomputer and an Acorn 6502 second processor. Interaction with the system was via a fixed-label dedicated keyboard.

2.2.2.2. Software

The simulation of the 'plant' was carried out by a continuous loop in the program which:

> Generated the values of the bottom-level process variables,
> Transferred the aggregated values to the monitor variables,
> Updated the pointers for the trend displays,
> Re-drew the currently selected trend,
> and performed various housekeeping and monitoring tasks at intervals,

This loop lasted half a second: the 'tick' length of the simulation. Keyboard input was buffered by the operating system and the buffer was polled regularly (many times per second) during all the above activities. Keystrokes were echoed immediately in the 'operation log' window. As soon as a complete command was received, the trend display would be blanked for the duration of the tick and then replaced by the newly selected display. The triggering of alarms were independent of the process 'tick', being controlled by the input-polling routine.

Perturbations in the plant were controlled by a 'script'. When the script signalled an event, the appropriate bottom-level variable would cease oscillating about its target value and begin a steady excursion which would, if unchecked, lead to an alarm after 40 seconds.

All valid commands were logged, and the plant output was recorded by logging its 'root mean square' average over 12 second periods. Thus both strategy and performance could be determined for each subject.

2.2.2.3. Script

Although the frequency with which these events were to occur had been preset, the variables themselves (be they Red, Blue, or Green) and their individual numbers (from zero to eight) were randomly selected. This was also applied to the direction the variables were sent off course (either as an increase or a decrease). From this basis the script was formed, with the events occurring evenly throughout the set. Figure 5 shows all of the possible configurations (script used in appendix 1).

RED		BLUE		GREEN	
0 1 2 3 4 5 6 7 8		0 1 2 3 4 5 6 7 8		0 1 2 3 4 5 6 7 8	
Increase	Decrease	Increase	Decrease	Increase	Decrease

Figure 5. Possible configurations in the script.

2.2.3. Task Analysis

Although the task was familiar to the experimenter, a formal Hierarchical Task Analysis (HTA) was carried out on the information collected on the task, to ensure that the entire nature of the task was encapsulated for the production of the training modules. In this instance it was used for the development of training (for further information of the use of HTA see Patrick, Spurgeon & Shepherd, 1985).

The data collection was carried out by the experimenter sitting next to a colleague who was also familiar with the task. The colleague described what he was doing as he performed the operations necessary to control the 'plant'. This verbal protocol was recorded in long hand on paper. The experimenter also asked for: clarifications, further details of knowledge required to perform specific actions, and the goals of the 'process controller' as appropriate.

The HTA was produced using an outline package called More™ on the Apple Macintosh™. From the HTA it appeared that the overall goal of the task was keeping a steady plant state. This goal consisted of three sub-goals, namely: monitoring the status of the output, identifying the locus of faults, and identifying alarm states. These are represented in Figure 6. Fuller details of the HTA can be found in appendix 2.

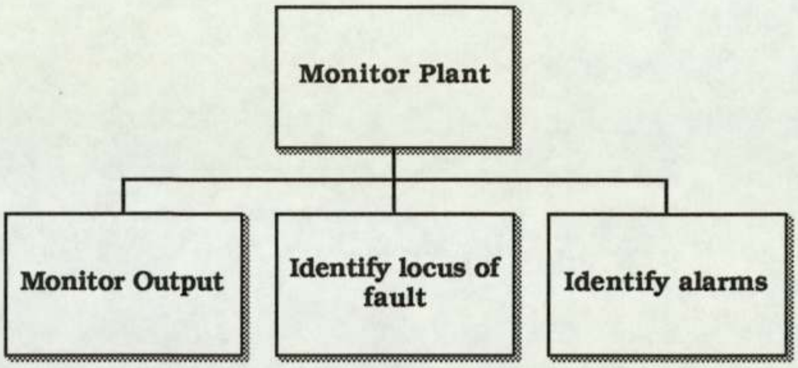


Figure 6. Top level HTA of process control task.

Although not explicit in the HTA, the knowledge required to perform certain functions such as; interrogation of plant hierarchy, and assessing the magnitude of the deviation, were made implicit in the process.
From the HTA the training modules were identified.

2.3. AUTHORING COURSEWARE

From the basis of establishing the training modules the process of authoring these into stand alone CBT began.

2.3.1. The Author

It should be noted that the author was a novice programmer, having only rudimentary programming skills. The visual language authoring system (Coursebuilder™) was new, and unknown to the author. However, the author was fully conversant with the WIMP interface, which was utilised by the authoring language.

2.3.2. CourseBuilder™

CourseBuilder™ is a visual language authoring system that was developed by Appleton, B. (1986) in the U.S.A. It is described by the developers as a 'knowledge navigator', and it allows an individual to create stand alone training. It has numerous facilities that enable interactive training, allowing the author to employ animation, sound and text output with input options of the mouse and keyboard. The interface encourages a top down approach to course creation, in an environment similar to MacDraw™ and MacPaint™ (as shown in figure 7). Despite all of the inherent advantages and ease of use of the authoring language, it did have its limitations. It required a lot of memory to store the training course. This became so large that it had to be stored as a series of separate documents running from a main application on the hard disc. It was also a very difficult environment within which to create a simulator, the development of which took considerable effort. This was because every possible state that the simulator could be in had to be predetermined and created in sprites (see appendix 3).

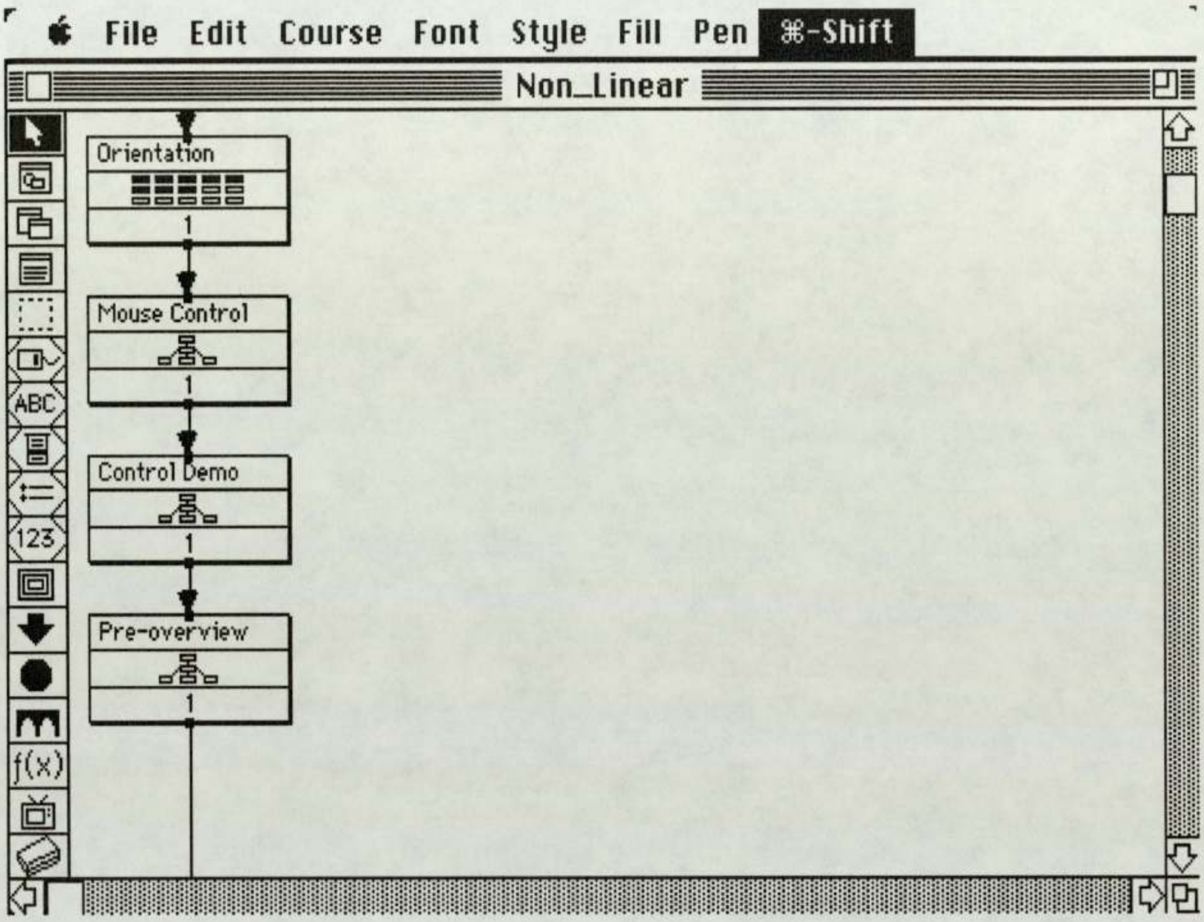


Figure 7. Example of Coursebuilder interface.

2.3.3. Benefits and Limitations of Coursebuilder™

As an authoring environment this language was relatively easy to learn. If the author was in possession of the skills required to work in Macintosh applications, then most of these skills would be transferable to the authoring task. The language provided a structured environment for the creation of courseware, and encouraged a top down approach to authoring. Being a purpose built language it also had the advantage of automatically timing and creating a report on the subject's progress through the training. In addition, the time between creating a piece of courseware and testing it was virtually instantaneous. However, the language did have its limitations. The visual analogy ran out at point where 'calculation boxes' (see figure 8) were introduced as a means of determining the place of sprites based upon input actions. Other functions such as hiding the cursor also relied on these calculation boxes.

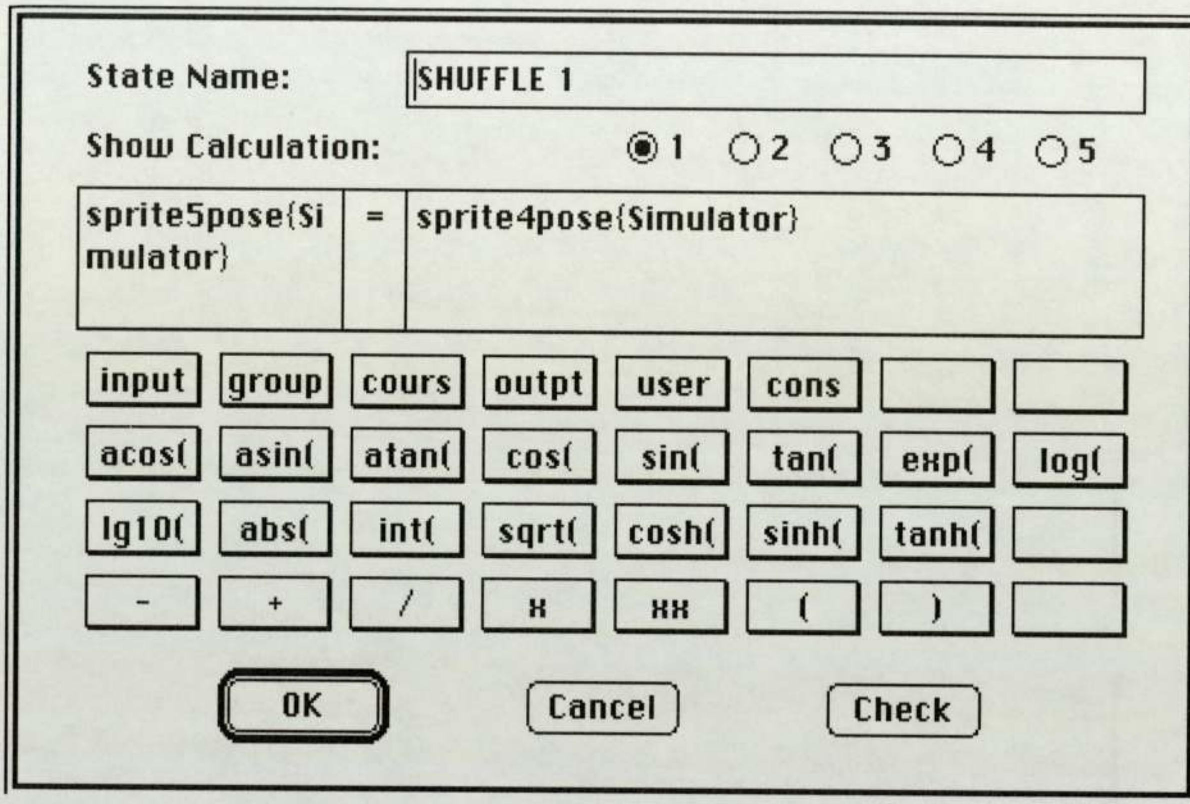


Figure 8. A 'calculation box' in Coursebuilder.

The stand alone courseware was also required a lot of memory, and a hard disc was absolutely essential for a course of any reasonable size. Finally the cost of the software was expensive when compared to that of a conventional language, approximately ten times as much.

2.3.4. Designing Courseware

The main guidelines followed in the design of the courseware were those of consistency and clarity. The screen was split into functional areas for text, graphics, and mouse buttons. This enables the subjects to be aware of the layout of the screen, which remained consistent. There were instances where these guidelines were not adhered to rigidly, mainly due to the small size of the screen, and this meant that text had to be overlaid on the graphics. When this was necessary, care was taken not to obscure the part of the graphic it was necessary for the subject to refer to.

2.3.4.1. Interaction

The courseware was designed to keep the subject interaction to a maximum. Therefore subjects were allowed to pace the presentation of instructional modules, and were required to interact in the practice modules.

The approach to instructional design was based on: task analysis (the consecutive breaking down of the task areas), elaboration (showing the sub-task as part of the whole), assimilation (providing the context and goal orientation) and mental models (giving the subject graphical models of the system, its functions and underlying concepts). The presentation of the material followed a simple to complex formula (as advised by Dean & Whitlock, 1988) following the consideration of instructional design theories (section 1.1.4.). In general the model for presentation was as follows:

a) Break topic down into individual parts
b) Present each component visually
c) Summary and rerun at end of presentation of instruction
d) Offer of a repeat of instruction
e) Practice operation/skill last instructed in
f) Feedback on practice session
g) Offer to repeat practice session
h) Next module.

2.3.4.2. Graphics

It is not necessarily a good approach in CBT to present text alone, and therefore the decision was taken to keep the text to a minimum whilst making the most of the graphical facilities. The task was primarily visual-spatial and relied more on procedural knowledge than declarative. Therefore it was important to have demonstrations using graphics. It was also found that it was much easier to show the relationships between the hierarchy of monitors graphically. Therefore, animation and simulation were used extensively throughout the course. The general guideline provided by Dean and Whitlock (1988) was not to clutter the screen. To comply with this and cope with the small amount of space allowed on the standard Macintosh™ screen, some simplification of the simulated equipment was necessary. The emphasis was placed on functional, rather than physical, fidelity.

2.3.4.3. Functional Areas

As mentioned previously the functional areas were kept consistent where possible. This included the presentation of text, graphics, the continue prompt, dialogue boxes for feedback, and the repeat/continue function.

Heines (1984) claims that there are four standard components of a display, which ideally contain:

- orientation information
- directions and responses
- error messages
- options.

To a large extent the functional areas of the screen were standardised as advocated by Dean & Whitlock (1988). This meant that as soon as the subjects had become familiar with the screen layout, this load on memory was reduced.

2.3.4.4. Supportive Environment

The training environment was designed to be supportive of learning. This meant that if subject made the wrong response, some explanation was offered either to guide them towards the correct response or to inform them why their response was incorrect.

In general, the human factors guidelines proposed by Hemel (1986) were followed in design. These are briefly, that CAI should incorporate the following principles:

- Brevity
- Consistency
- Flexibility
- Compatibility
- Responsiveness

The advice of Fitzgibbon and Patrick (1987) was followed in the construction of an overview screen for all conditions. This allowed subjects to see each module in the context of the goal oriented nature of the task, and therefore retain the correct context for learning.

2.4. TRAINING MODULES

Using the HTA, one introduction, seven instruction, and seven practice modules were identified. These are presented next in the order they appeared in the linear condition.

2.4.1. Orientation

This module introduced subjects to the goal of the training, and explained the basic principle of information propagating through a plant hierarchy. Figure 9 illustrated this principle by animating the movement of liquid from one vessel to another. When the first vessel became empty, this led to a series of alarms propagating up through the alarm hierarchy until the highest level was reached. Subjects were informed that this was a useful principle for them to remember in the ensuing training task. This module also allowed subjects to practice basic mouse interaction, such as moving boxes and clicking on buttons, both of which were required in the practice modules. Figures 10 and 11 illustrate the screens shown to subjects.

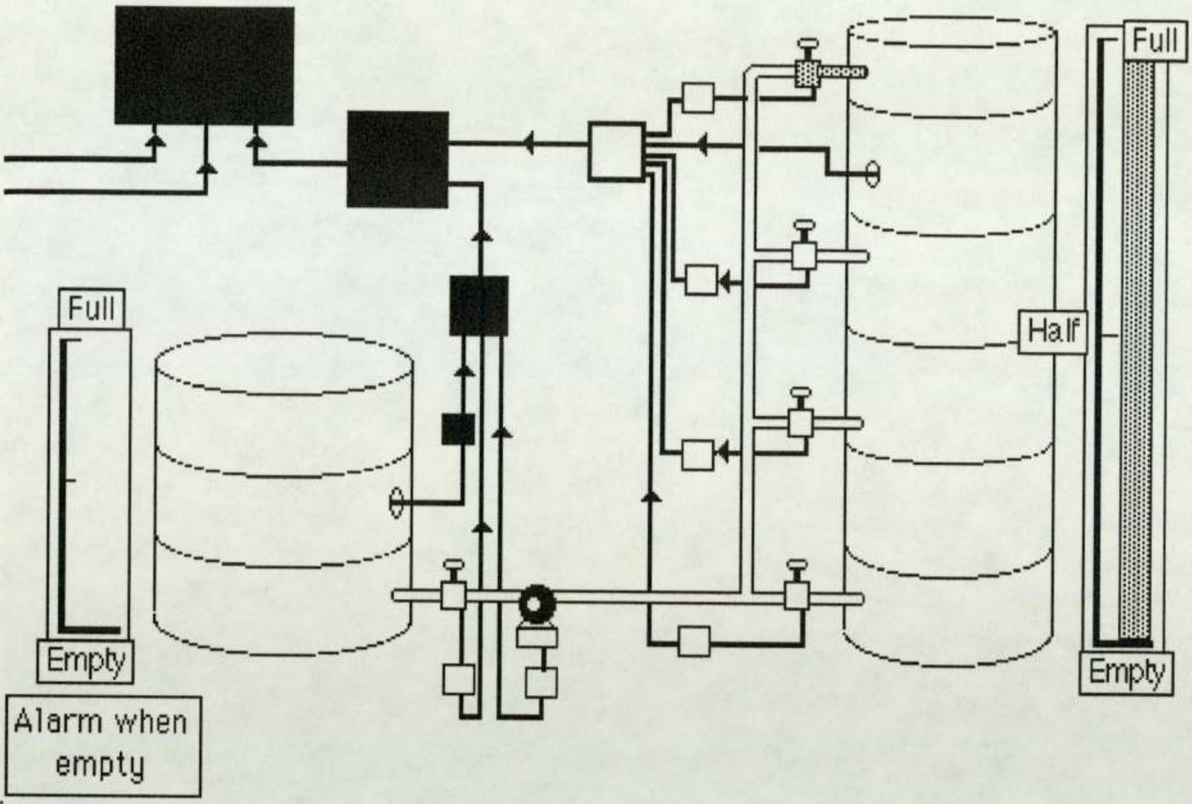


Figure 9. Example of basic plant hierarchy principle.

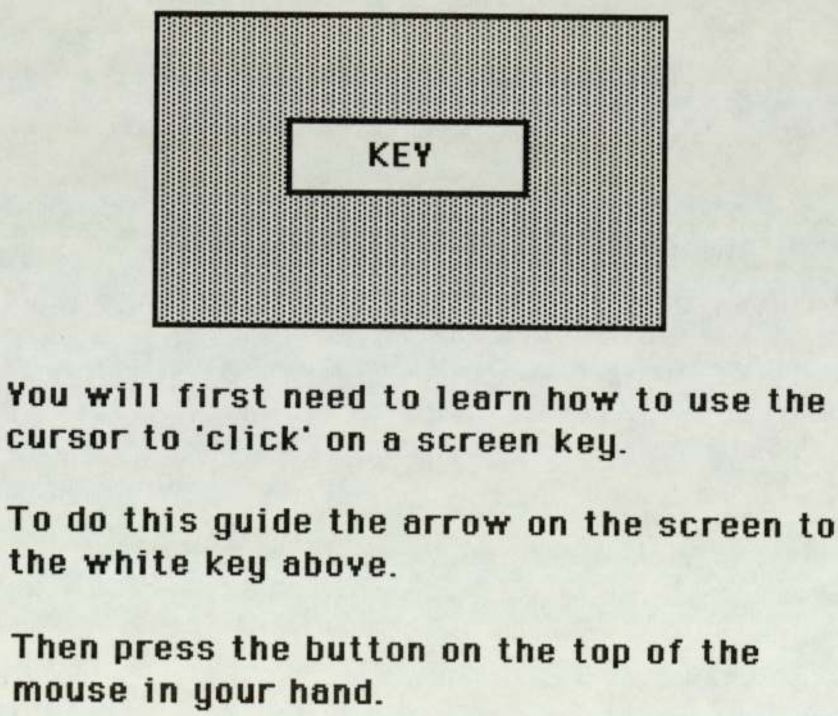
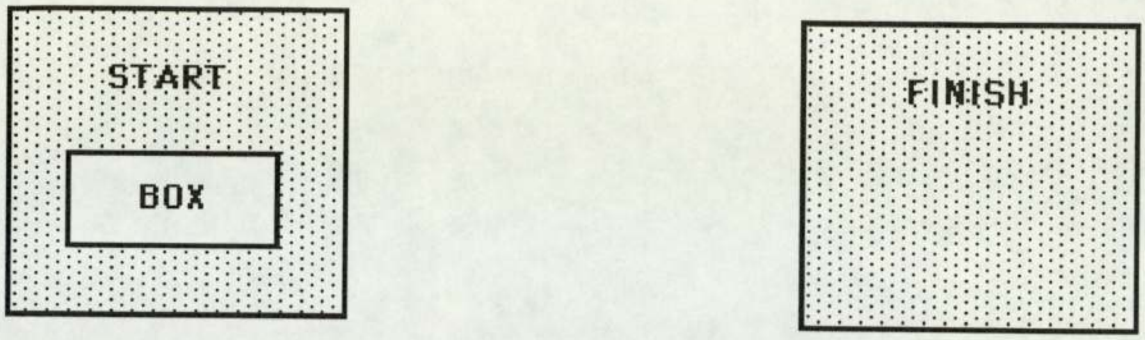


Figure 10. Learning to use the mouse.



Now you will need to learn how to drag boxes.

Guide the arrow on the screen to the BOX in the START position and hold down the button on the mouse.

Then with the button held down, drag the box to the FINISH position on the screen.

Figure 11. Learning to move graphics.

Subjects were also introduced to the operation of the repeat/continue function, which was a dialogue box that enabled them to run through a section again if they wished to, by clicking on the appropriate radio button (figure 12).

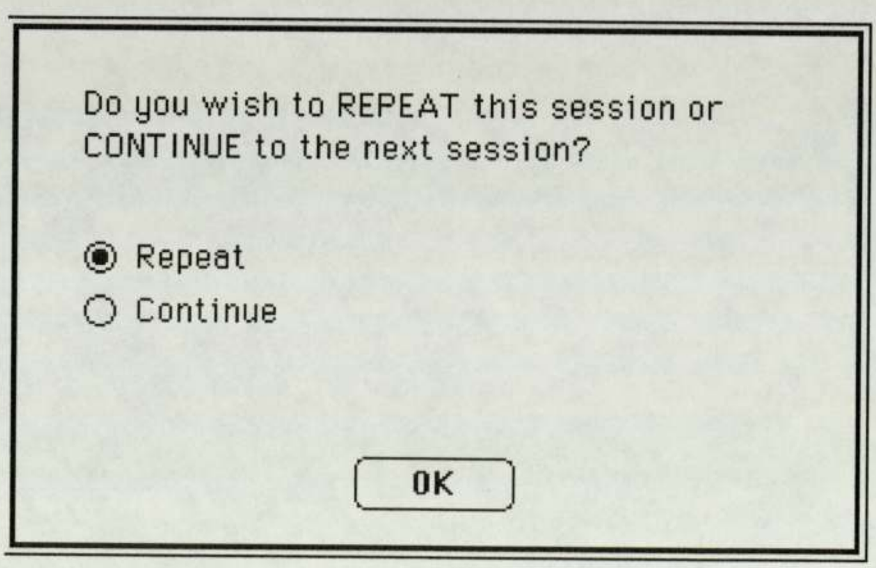


Figure 12. Example of the repeat/continue dialogue box.

2.4.2. Principles Instruction

This demonstrated the hierarchical nature of the plant indicators and processes by building the structure in a top down manner from the output to the underlying processes. The final picture is shown in figure 13.

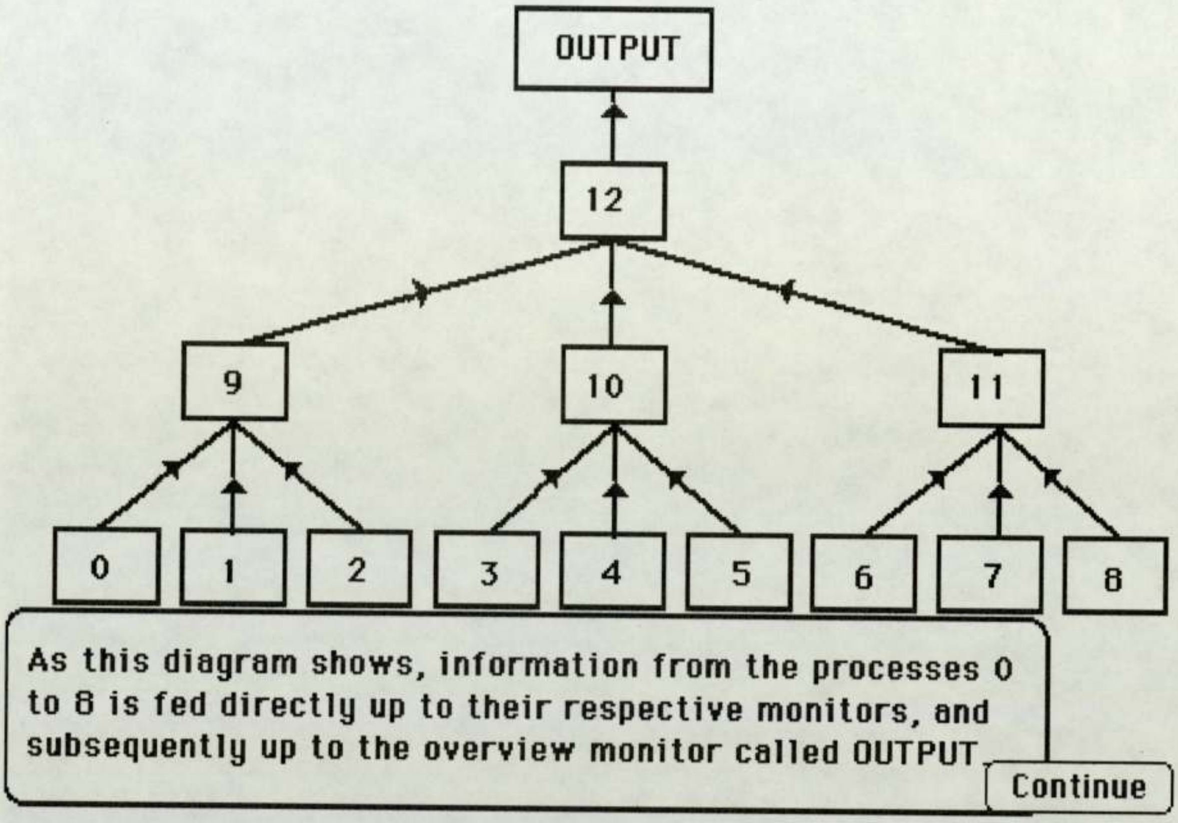


Figure 13. Example from principles instruction.

2.4.3. Principle Practice

The subjects were required to build the hierarchy by moving boxes which were presented in a random order below an outlined grid. If this operation was performed successfully, then it was presupposed that the subjects had understood the concept. If any of the boxes were put in the wrong place then subjects were informed which ones needed to be changed. Figures 14 and 15 show the two practice tasks.

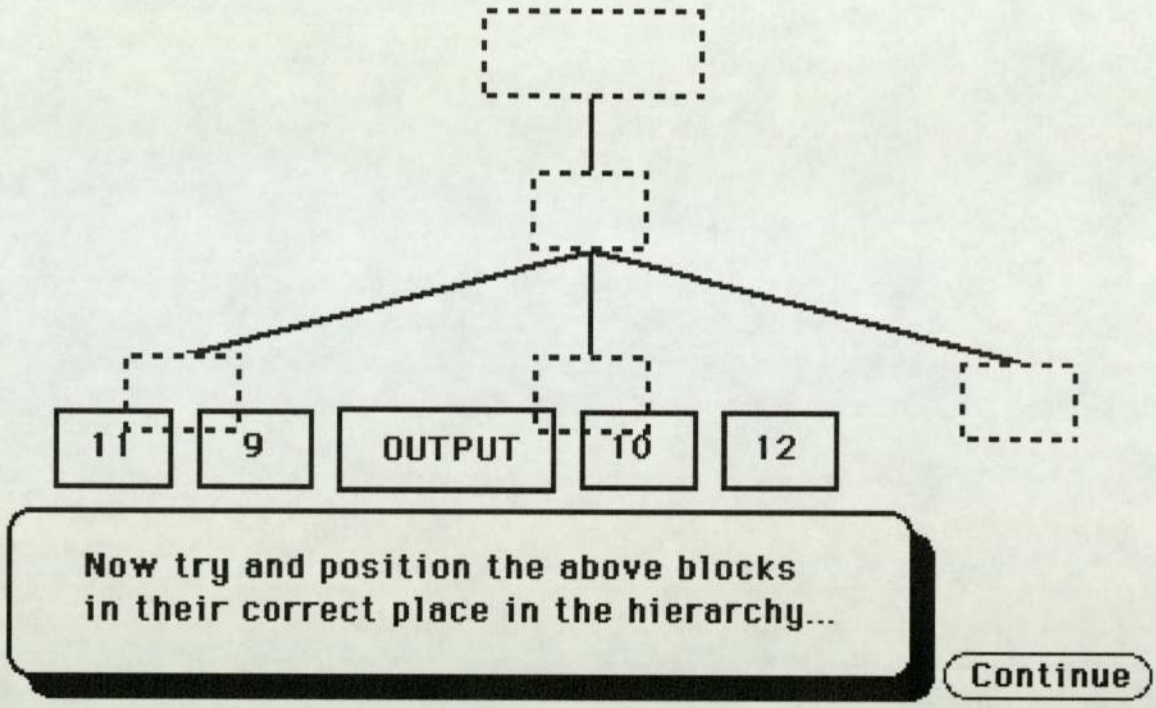


Figure 14. Example A from principles practice.

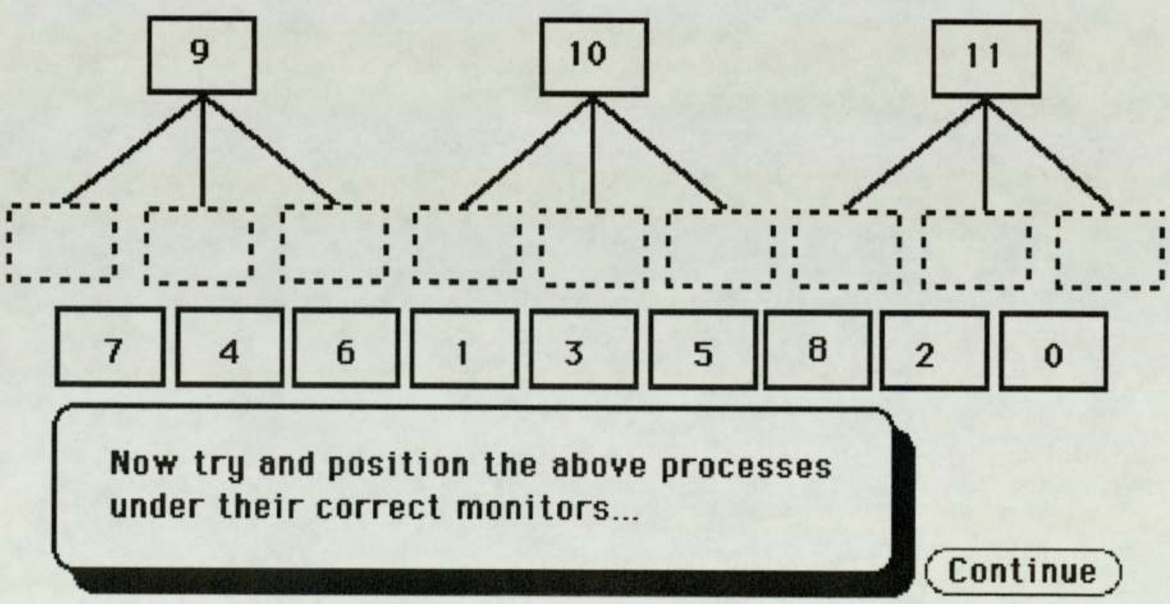


Figure 15. Example B from principles practice.

2.4.4. Screen Instruction

This explained the layout of the screen, and the functions performed by different areas. As figure 16 shows, the representation of the screen had

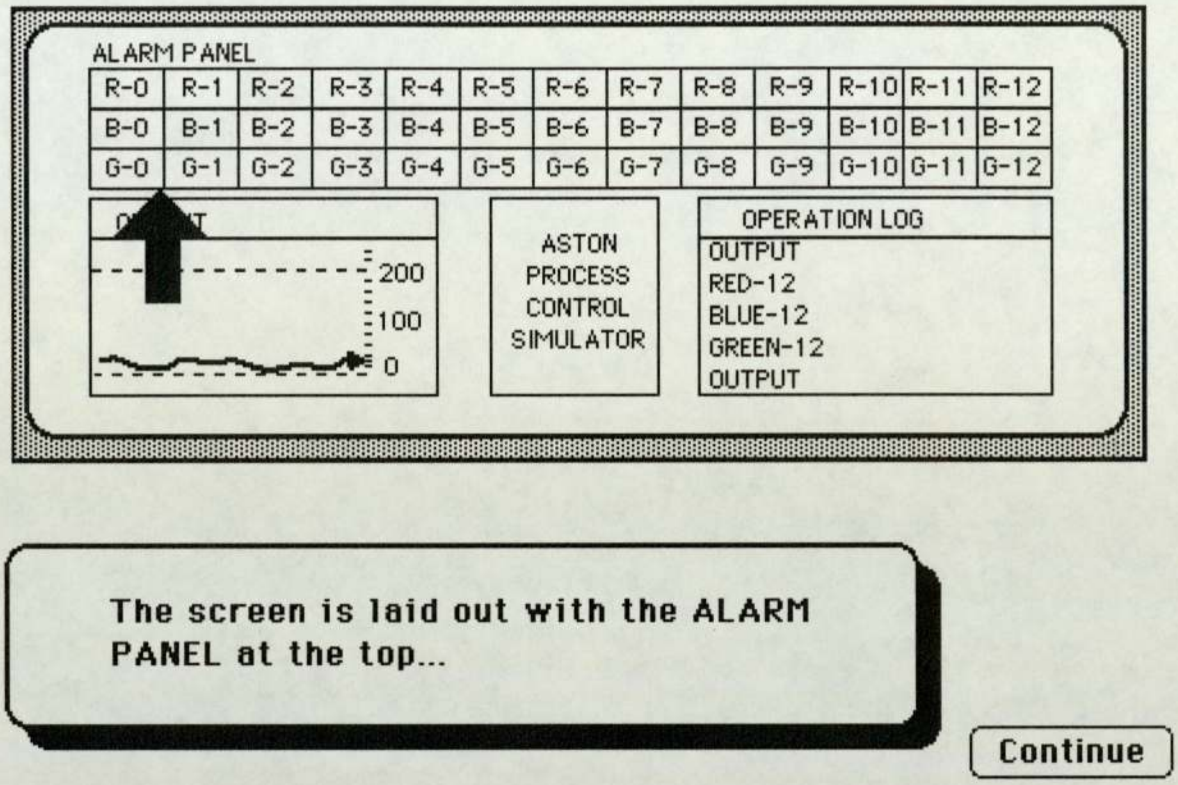
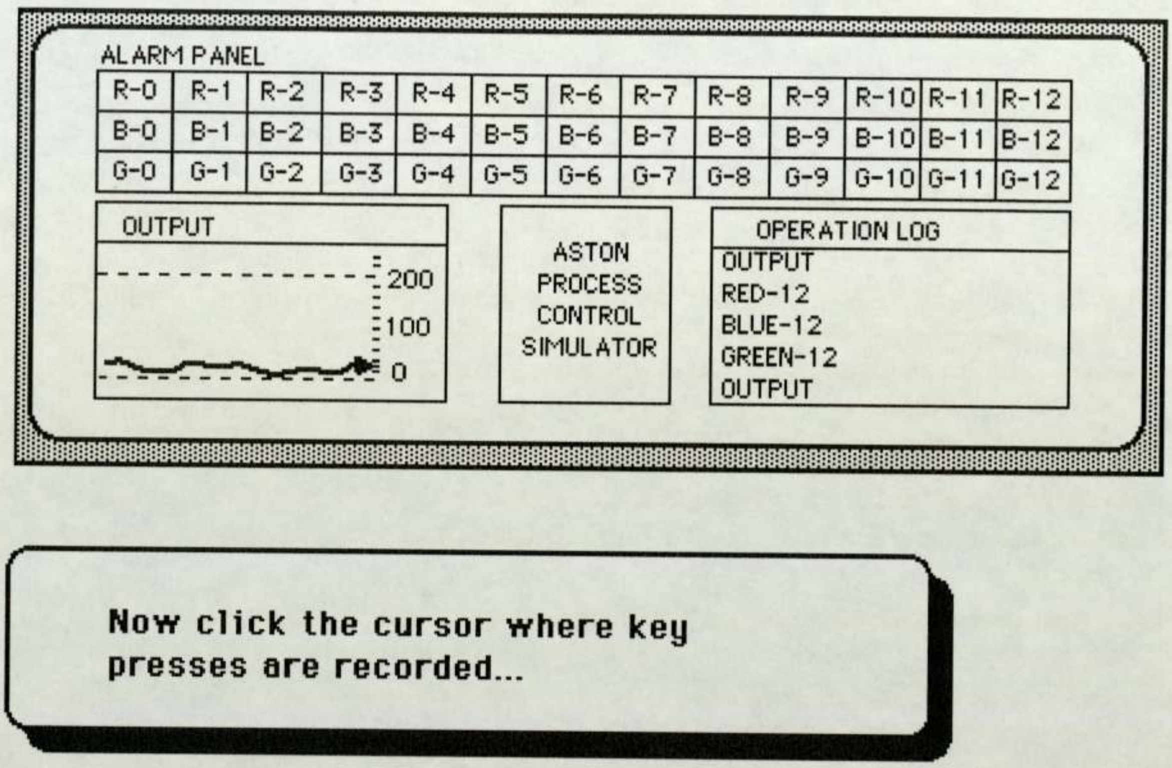


Figure 16. Example from screen instruction.

to be compressed and was presented in monochrome rather than colour. However the spatial relationships were consistent, as were the functions. This module only required the subject to pace the instruction by clicking on the 'continue' button when they had read the text. The experimenter had decided to introduce a slight delay between the presentation of the text and the appearance of the 'continue' button. This was intended to ensure that the subject read the text rather than continuously pressing the 'continue' button.

2.4.5. Screen Practice

Subjects were asked questions about the function of an area of the screen. They had to click the cursor in the area of the screen that corresponded with their answer.



<u>Figure 17. Example from screen practice</u>

Figure 17 gives an example of a question being asked of the subject. This particular question would require the subject to click the cursor in the area of the operation log. If they did this, then a dialogue box would appear to inform them that that they had responded correctly. However if they clicked the cursor in the area of the alarm panel or output graph then a dialogue box would appear to inform them that this was the wrong choice, tell them the function of that particular area and ask them to try again. If they clicked the cursor outside an active area, then they would just hear a 'beep' meaning that they had not hit their target. The order of the questions was randomised so that if they attempted the practice session more than once it would be unlikely that they would get the questions in the same order twice.

2.4.6. Keyboard Instruction

The layout and functions of the keys on the dedicated keyboard were explained as shown in figure 18.

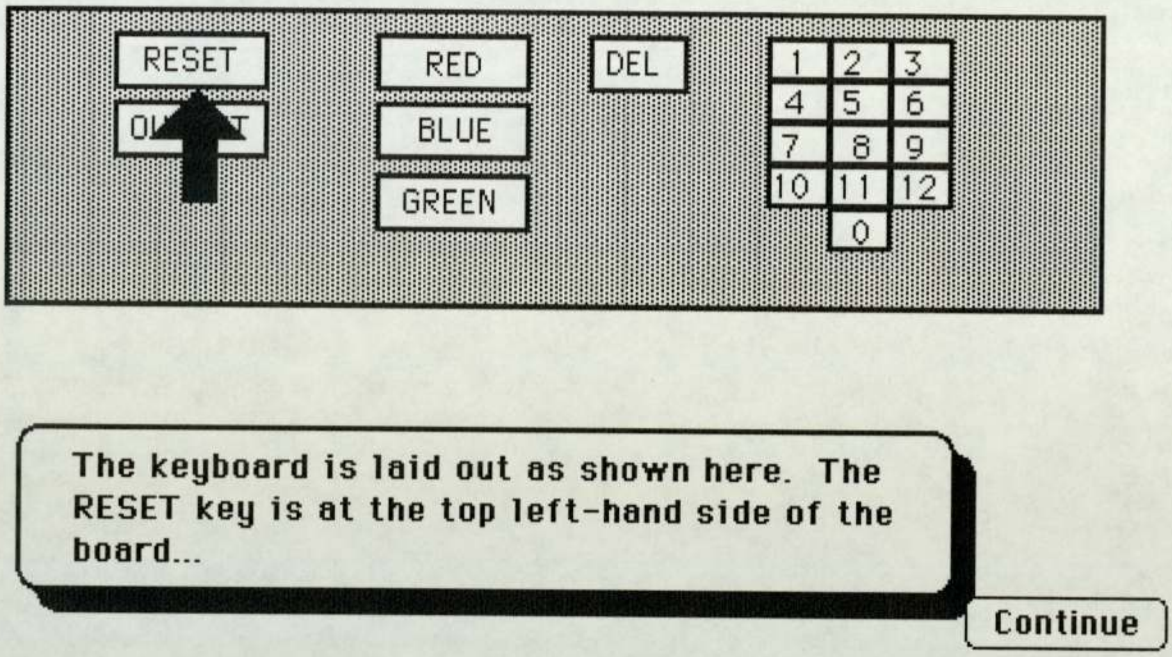


Figure 18. Example from keyboard instruction.

In the keyboard instruction phase, each key was presented in turn with accompanying text. It was first presented in relation to the rest of the keys, then the rest of the keyboard was removed and the function of the key was presented in more detail. This was so that subjects would first see the key as part of the keyboard, and then concentrate on its purpose without being distracted by the other keys. The colour keys were considered as a group all performing a similar function rather than each being considered in isolation, as were the numerical keys.

2.4.7. Keyboard Practice

The subjects were asked questions regarding which keys they would use to perform certain functions. In response they had to click the cursor on the appropriate key. The order of the questions was randomised.

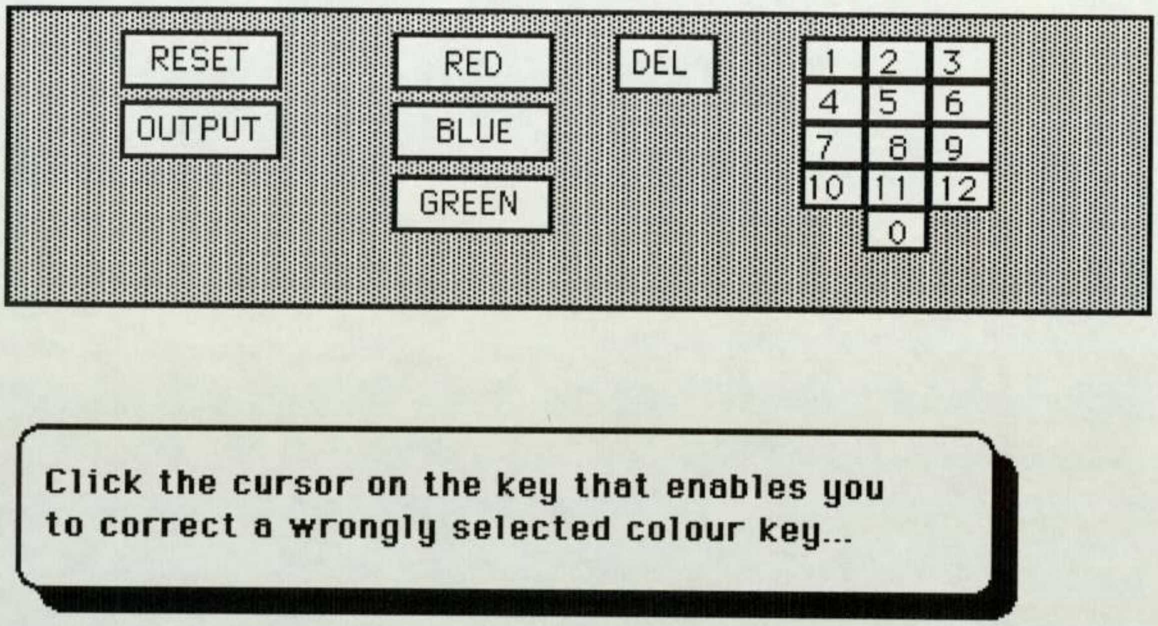


Figure 19. Example from keyboard practice

For the purposes of the subject practising using the keyboard, each representation of a key behaved as a separate key. In a similar manner to the screen practice session, subjects selection of a key could be either correct or incorrect. If, in the example shown in figure 19, the subject has selected the key labelled 'DEL' then a dialogue box would have appeared to inform them that they were correct and that the key they chose does enable them to remove a colour code selection. However if they had chosen any of the other keys they would have been informed that this choice was incorrect, the function of they key explained, and asked to try again. If they had missed any of the key areas, then a 'beep' would inform them of this. The order of the questions was randomised so that if they attempted the practice session more than once it would be unlikely that they would get the questions in the same order twice.

2.4.8. Monitor Output Instruction

This demonstrated the procedure performed to view the overall status of the plant via the 'output' screen by selecting the 'output' key.

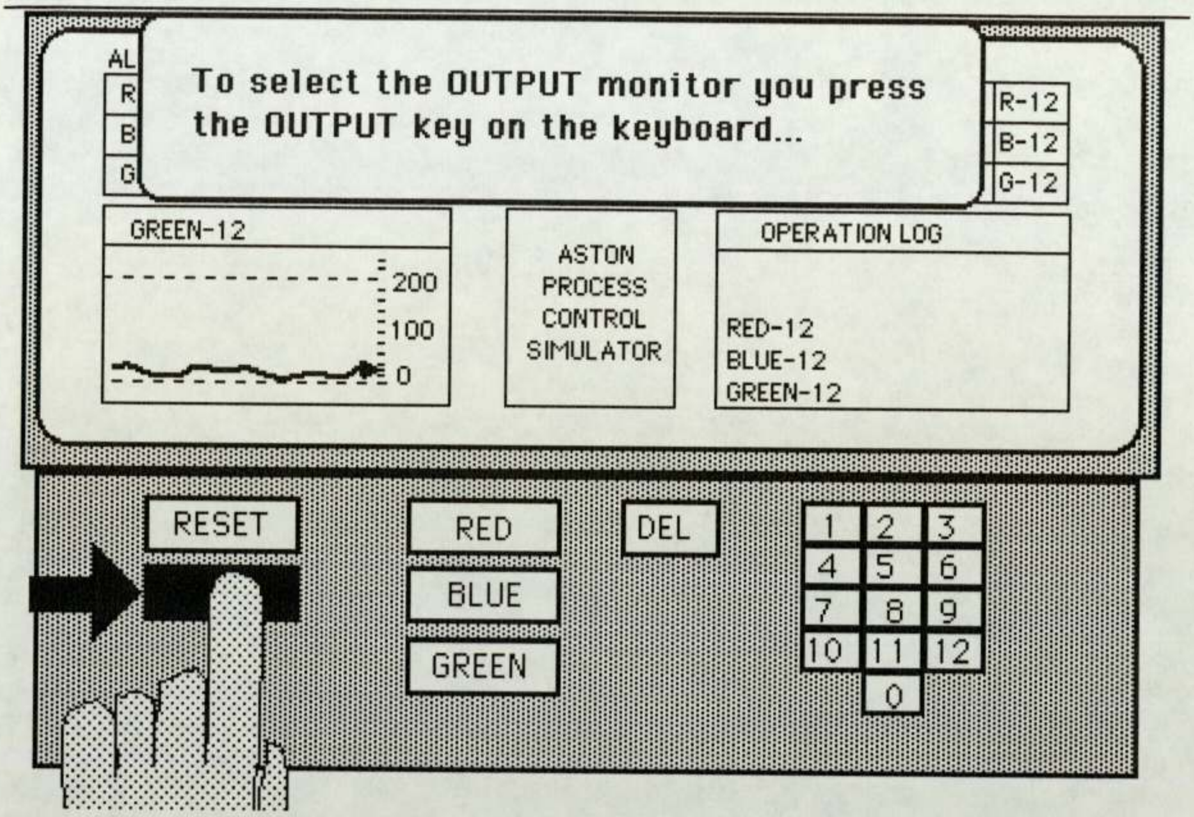


Figure 20. Example from monitor output instruction.

Figure 20 illustrates the beginning of the animation instructing subjects in the procedure of monitoring the plant output from the highest level. This takes the principle from the model of information propagation provided in the initial orientation module. By selecting the output key on the keyboard, subjects are shown that the output graph is displayed showing the overall plant status. The key selections are shown in the operation log correspondingly.

2.4.9. Monitor Output Practice

Subjects were required to perform the appropriate action to view the overall plant state. The correct action resulted in the output graph being displayed and the key selection recorded in the operation log.

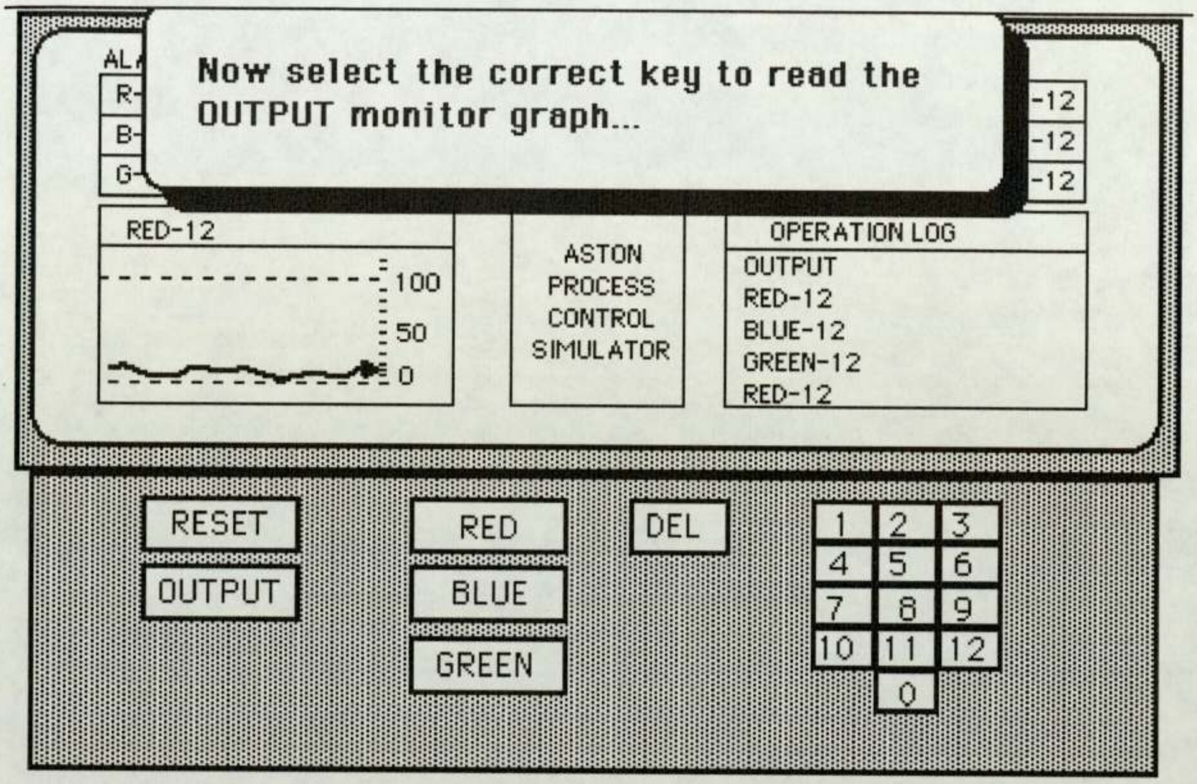


Figure 21. Example from monitor output practice

In the practice module subjects are shown the screen in figure 21. By selecting the output key via the mouse a subsequent dialogue box informs them that their action was appropriate. As with the previous modules, an incorrect action is also accompanied with an appropriate explanation together with an encouragement to try again.

2.4.10. Alarm Instruction

The procedure for responding to the activation of the alarm panel was demonstrated, showing subjects how to cancel the alarm.

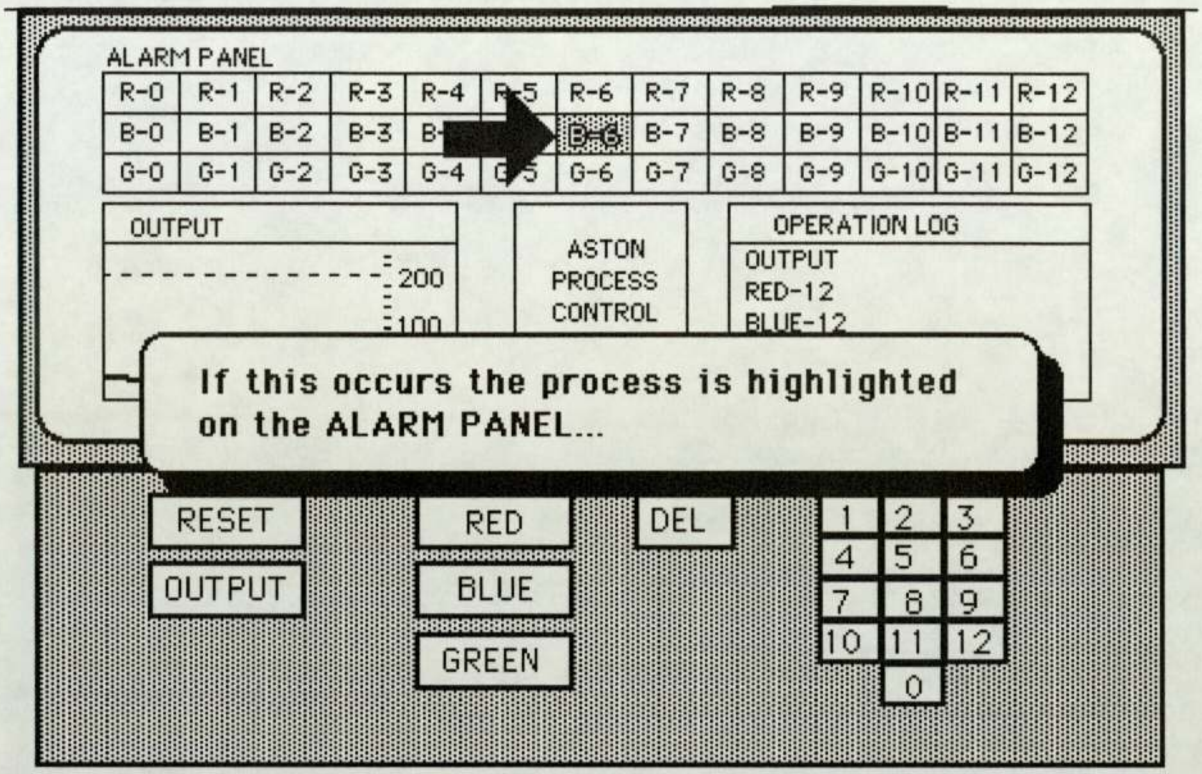


Figure 22. Example from alarm instruction.

Like the other instruction modules this relied upon animation to explain the procedure. Figure 22 shows the alarm panel displaying 'B-6' in the alarm state. The subsequent frames showed subjects the procedure to be adopted to deal with this fault. This consisted of selecting the code of the offending alarm (BLUE 6) to acknowledge it, and then to select the 'RESET' key to reset the alarm.

2.4.11. Alarm Practice

The subject was required to reset a process that had entered the alarm state and activated the alarm panel. Correct procedural action resulted in the alarm panel being deactivated.

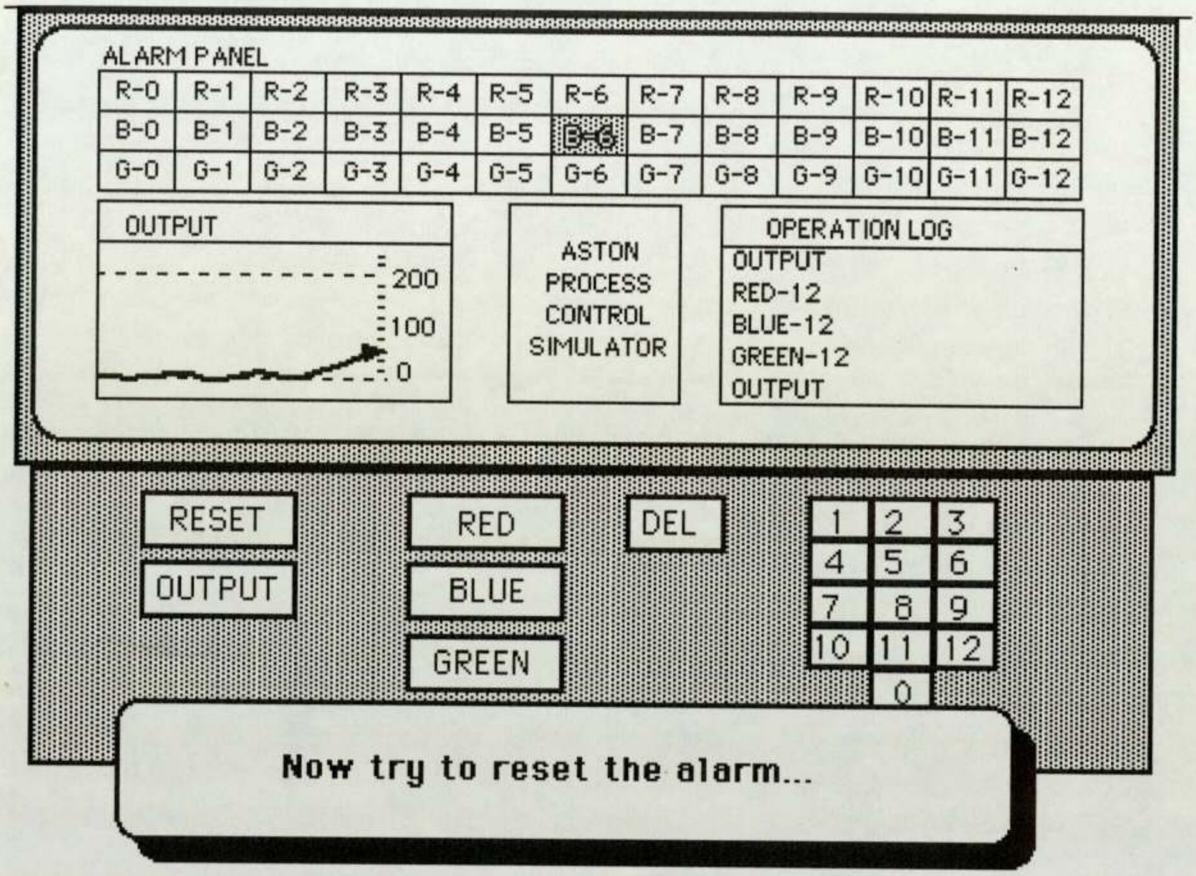


Figure 23. Example from alarm practice.

In this module the subjects interaction through the keyboard via the mouse led to changes on the representation of the screen. These changes were exactly the same in functional terms as those on the real operational equipment. So that selection of the alarm code from the represented keyboard were listed in the operational log and led to the presentation of the corresponding trend graph. Similarly, selection of the 'RESET' key was recorded in the operation log and returned the trend graph to normal, cancelling the alarm.

2.4.12. Delete Instruction

In this module the subject was instructed how to remove an incorrectly selected colour code input from the operation log.

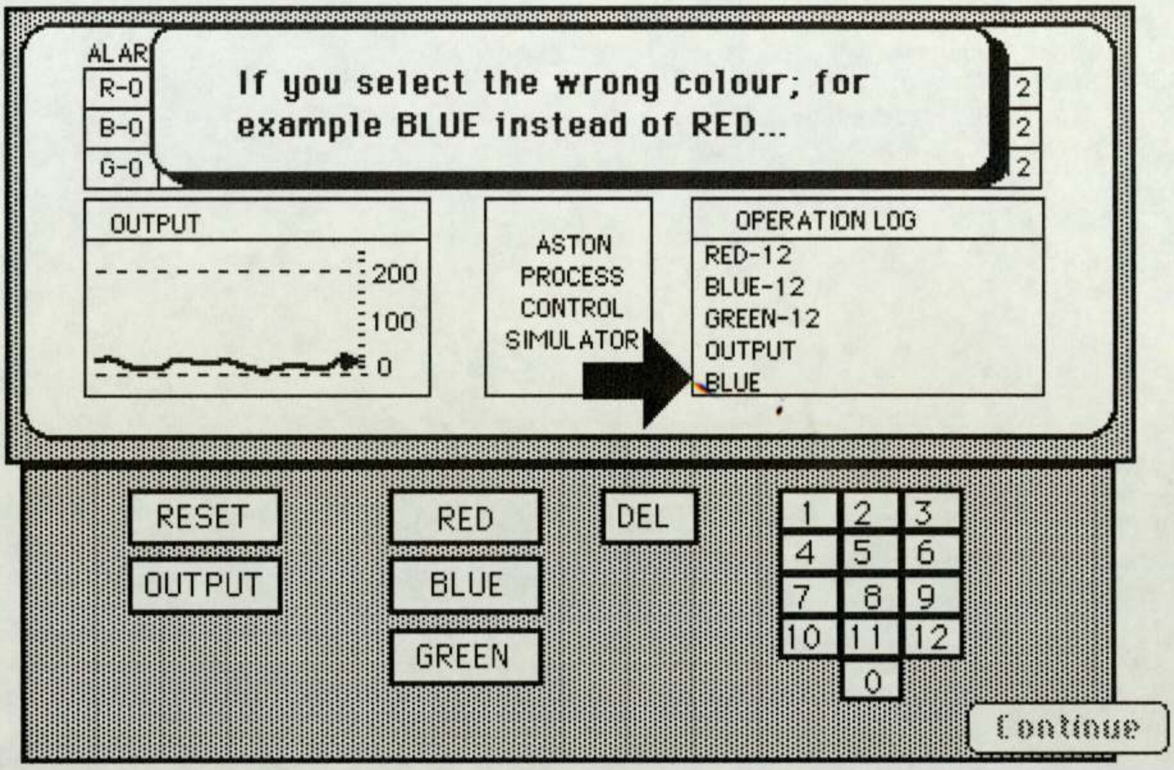


Figure 24. Example from delete instruction.

Figure 24 shows the first frame that was presented to subjects in this module. Subsequent frames demonstrated that by using the 'DEL' key the 'BLUE' part of the code could be removed and replaced by another code such as "RED' or 'GREEN'. They were also reminded that it was not possible to remove the numerical part of the code, because once that had been entered the search was started for the relevant graph.

2.4.13. Delete Practice

This module required subjects to remove a colour input from the operation log. An appropriate response would change the appearance of the operation log in line with that of the real equipment.

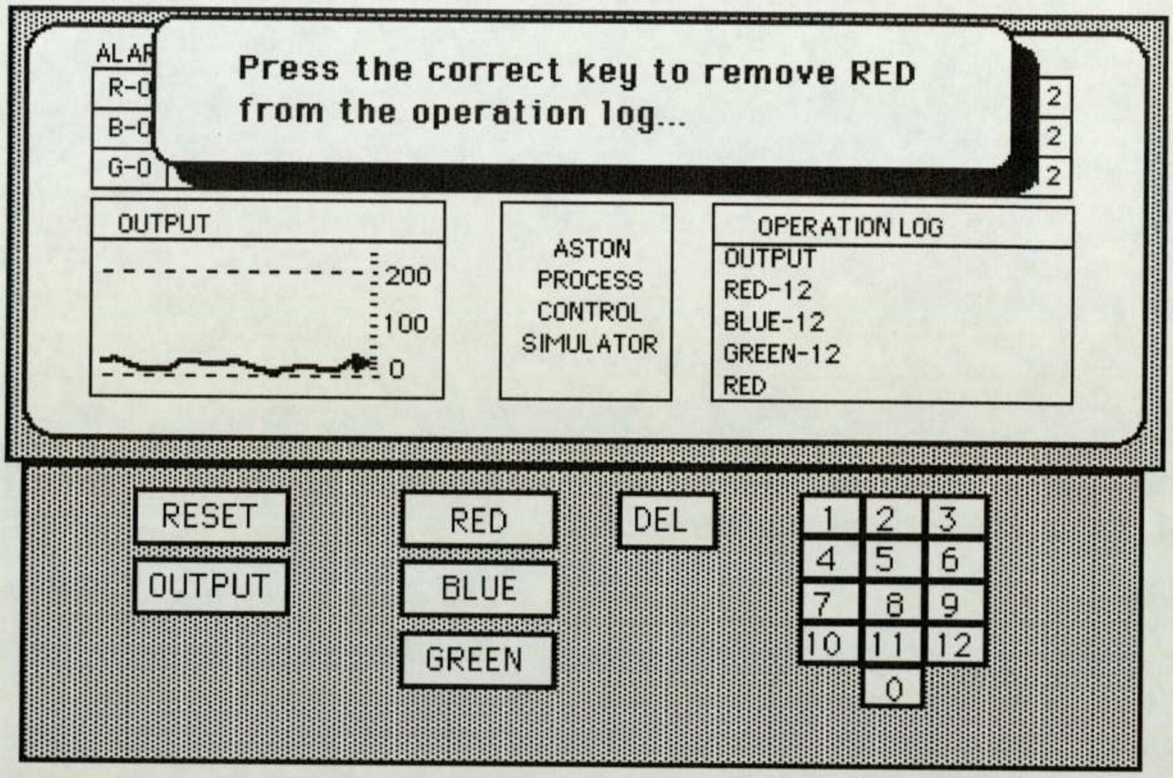


Figure 25. Example from delete practice.

For example as shown in figure 25, by selecting the 'DEL' key the subject would remove the code 'RED' from the operation log. This was the required action and resulted in a dialogue box been presented to the subject informing them that they had performed the procedure correctly. Any other key selection would result in a dialogue box telling them that this action was incorrect, why it was incorrect, and asking them to try again.

2.4.14. Fault Finding Instruction

This module demonstrated the optimal procedural strategy that enabled efficient interrogation of the plant hierarchy to locate and reset a deviant process, before it enters the alarm state.

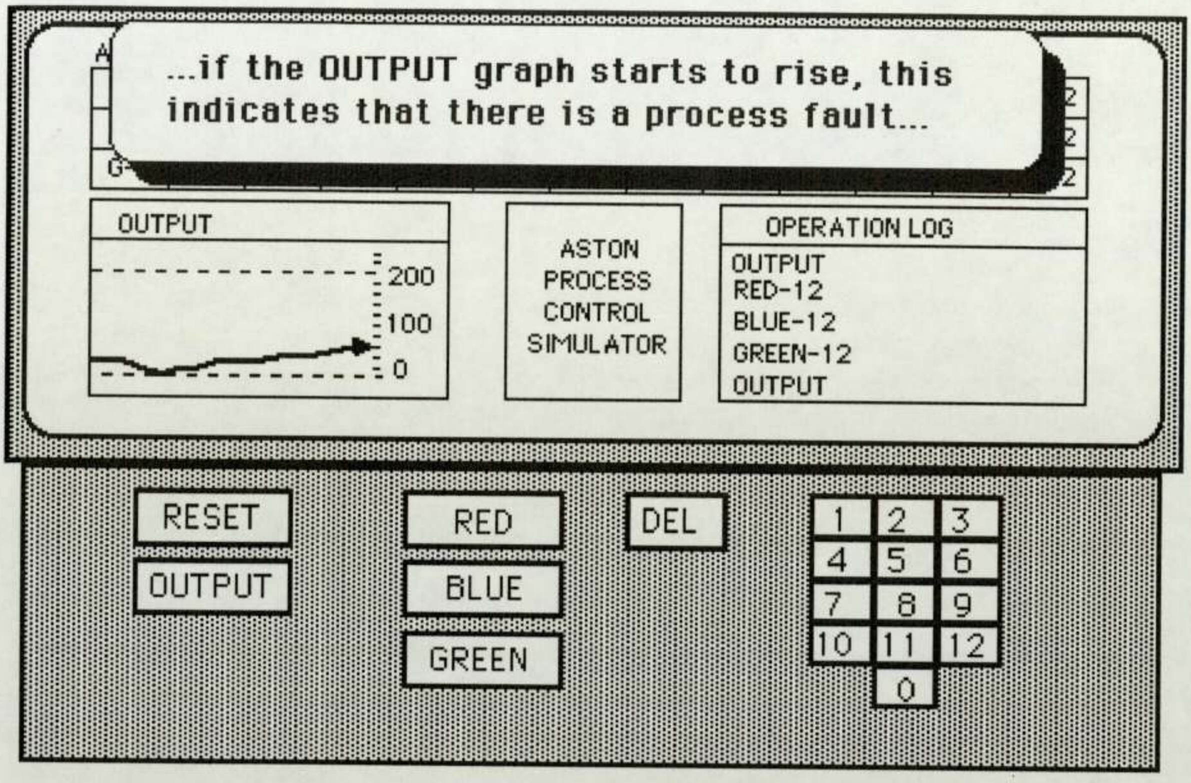


Figure 26. Example from fault finding instruction.

As figure 26 illustrates a rise in the output status of the plant shows that there was deviation occurring somewhere in the process indicators. Subjects were shown a breadth first search strategy for investigating this. This procedure demonstrated that the most effective method of finding the faulty process was to move from the 'output' graph in a systematic way through the monitor hierarchy. A typical search might be to examine the state of monitors 'RED-12', 'BLUE-12' and 'GREEN-12' in order to find the largest discrepancy. With this established the sub-tree can now be investigated further. For example if 'RED-12' shows the largest discrepancy the next step would be to examine 'RED-9', 'RED-10' and 'RED-11'. Again the largest discrepancy can be investigated further. For example if this was 'RED-9' then 'RED-0', 'RED-1' and 'RED-2' would be called. The process(es) that were away from normal state could the be 'reset'.

2.4.15 Fault Finding Practice

Subjects were required to interact with a reduced fidelity simulation of the task equipment. Physical and temporal fidelity were low, whilst functional fidelity was high. Their task was to locate the source of the deviation and reset the process.

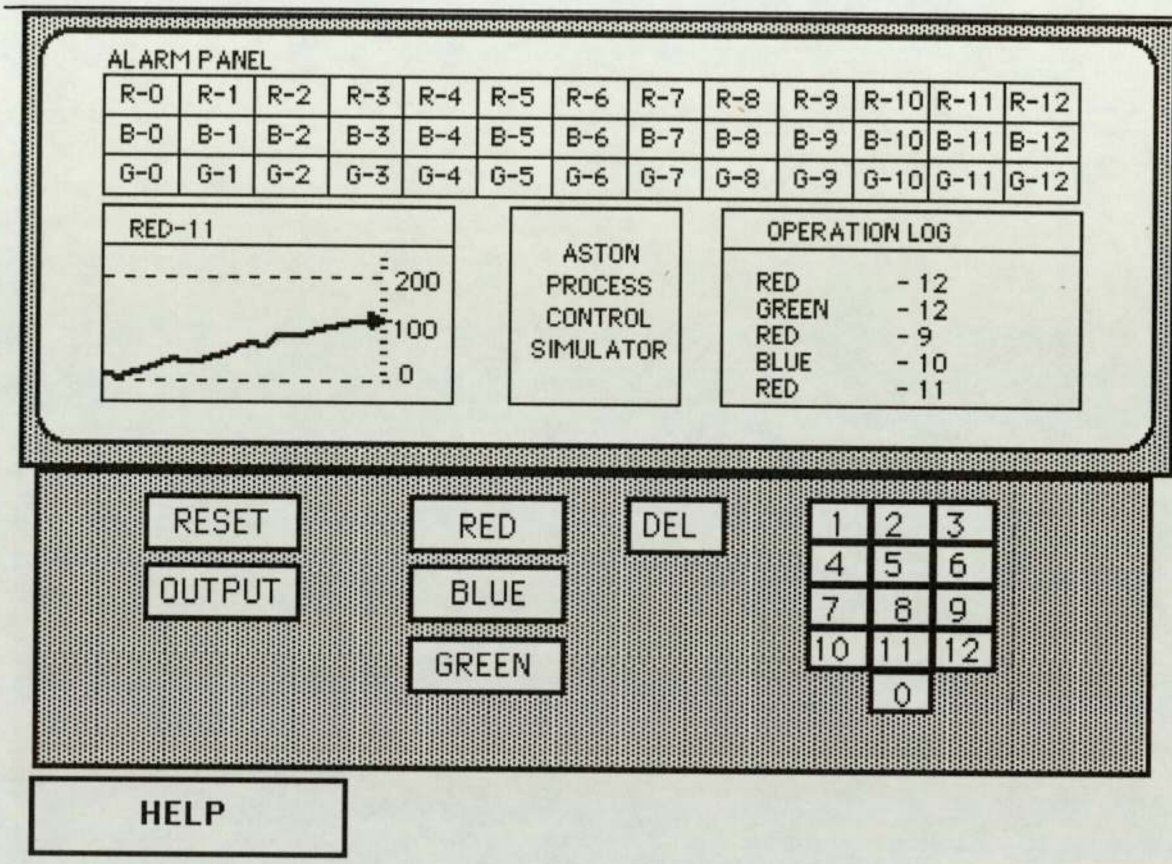


Figure 27. Example from fault finding practice.

Support and help was provided by the training package. Following on from their training, subjects could employ the same search strategy demonstrated to them to interrogate the monitor and process hierarchy. The training software was able to record their interaction (as it was for all of the training modules) to see if subjects were successful. These data could then be analysed later.

2.4.16. Overview

In between each of the instruction and practice module, subjects were referred to an overview screen. This was used for the purposes of continuity, and to ensure that the presentation of the linear and non-linear conditions was as close as possible. In the linear condition the overview screen announced what was coming next, for example:

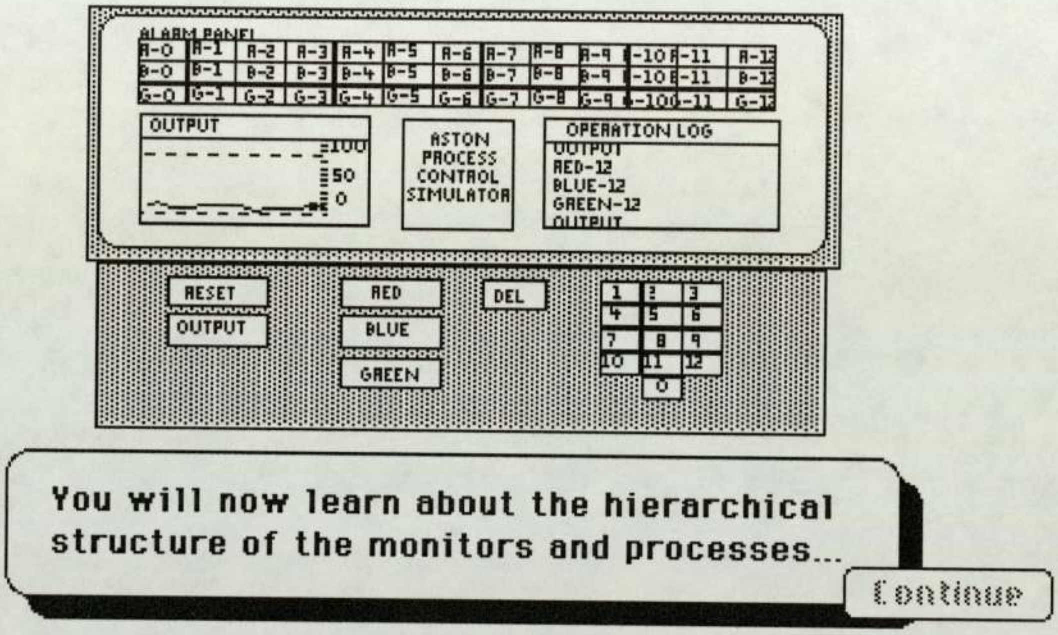


Figure 28. Example of between modules overview.

Whereas in the non-linear condition the overview screen allowed subjects to select what they wanted to view next (see section 3.2.2.2.).

2.5. COURSEWARE PILOTING AND REVISION

The courseware was micro-tested during construction by the author. This was done by running individual bits of the courseware during the development to see how it performed. In addition, a macro-test (running the whole of the courseware in one session) was necessary to see how others responded, and to test the robustness of the whole course. Five subjects were recruited at this stage specifically for this purpose. For the first three pilot studies, one for each condition, the author was present. Inevitably some changes were necessary, these are summarised below:

Fault 1. Student report file not being saved.
Solution. Link documents to application with a return to application at the end (as shown in figure 29).

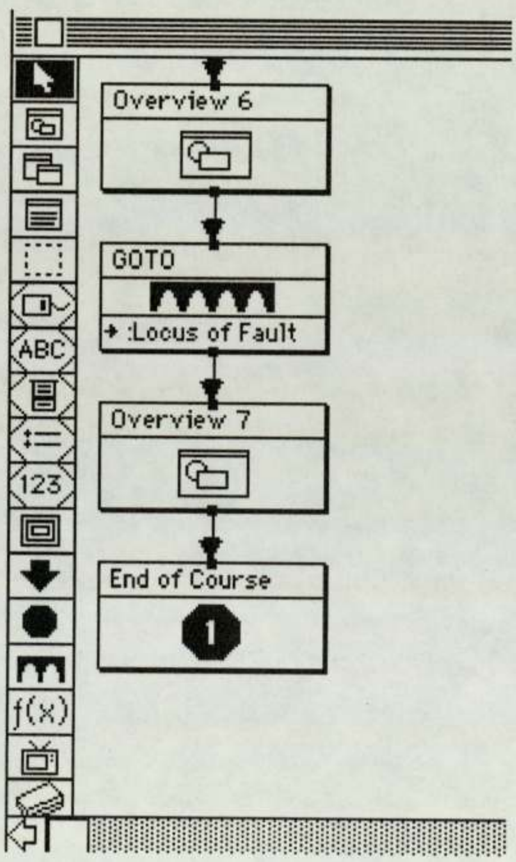


Figure 29. Solution to course report not being saved.

Fault 2. One SA question in non-SA condition.
Solution. Remove SA question from non-SA condition.

Fault 3. Missing 'hot' areas in Principles.

Solution. Put outline box in 'hot' area (as shown in figure 30).

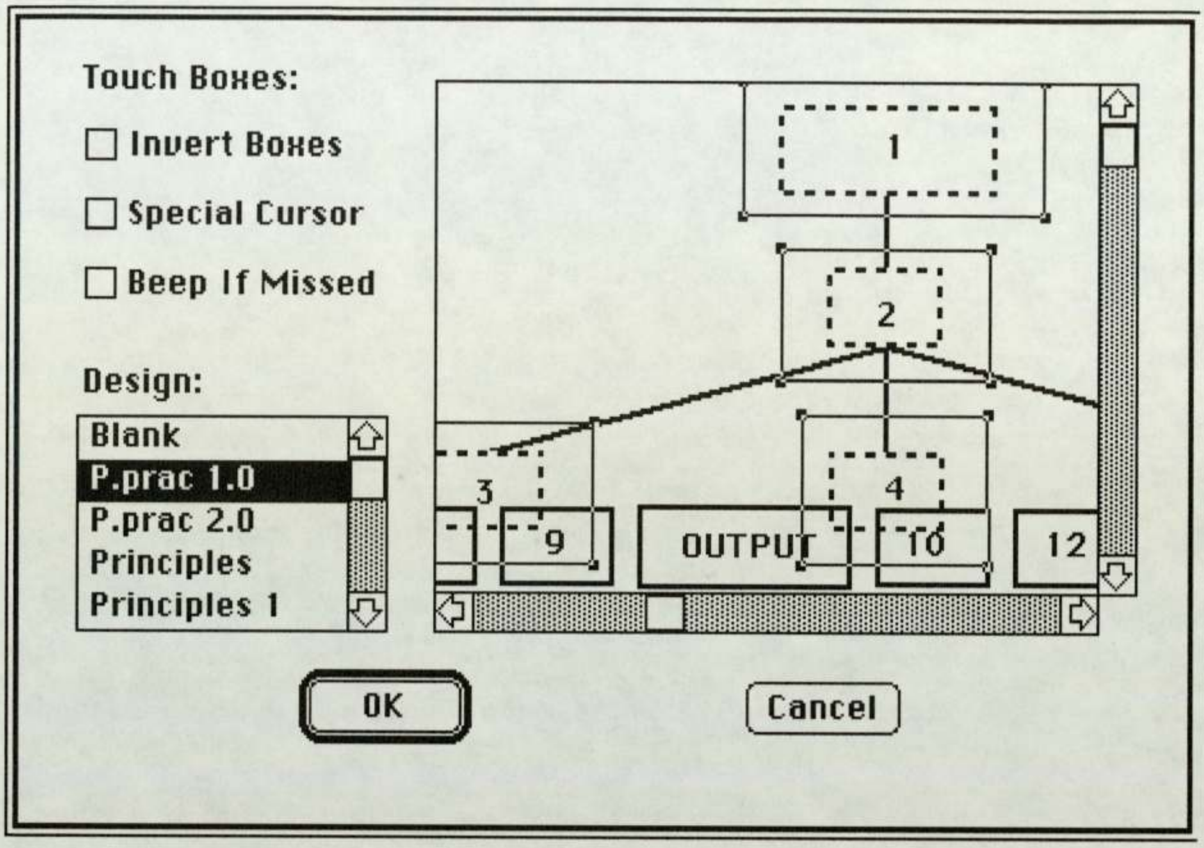


Figure 30. Solution to subjects missing 'hot' areas.

Fault 4. Subjects lost at simulator.

Solution. Instructions prior to engagement.

Following these revisions two more subjects were employed to undergo the whole of the training and transfer task without the author present. This evaluation showed no further faults. The courseware was therefore robust enough to be to implemented.

3. METHOD

The method chapter explains aspects pertinent to the experimental methodology of this thesis. This covers: the selection of subjects, experimental design, procedure adopted, equipment used and measurements taken. There were three conditions in this empirical study: control, non-linear and self-assessment. The experiment relied heavily upon computing facilities, and therefore it was possible to record most of the subjects activities.

3.1. SUBJECTS

A total of 72 subjects were employed. Five subjects were employed in the pilot study, four males and one female. The pilot study was run when the main development of the courseware was complete, to test the adequacy of the instructions and the robustness of the system. Some changes were made, the last pilot subject requiring no changes to be made. 67 subjects were employed to complete the main investigation. 35 were female and 32 were male. Data from 60 were used in the main analysis. Twenty were run in a linear self assessment condition, twenty in a linear condition without self assessment and twenty in a non-linear condition. Data for 7 subjects were rejected for three reasons. The data were lost for three subjects due to the program failing to save it (1 male and 2 female). The courseware program crashed losing data for two subjects (2 female). Finally, two subjects failed to return for the retention session of the task investigation (1 male and 1 female). All the subjects were undergraduates at Aston University, and the groups were matched for sex. Subjects were alone in laboratory cubicles during their participation in the investigation. Subjects were paid £5.00 for their participation. Subjects were self selected, to the extent that their response to the 'advertisement' publicising the study led to their inclusion. The only requirement was that they be of undergraduate educational level. There was no requirement of computer literacy.

3.2. DESIGN

This investigation was concerned with three main lines of comparison. Firstly there was a comparison of subjects in the linear and non-linear conditions. There was then a further analysis of the non-linear condition data. Finally there was a comparison of subjects in the self assessment condition with those subjects without self assessment. The experimental design was:

a) Linear x Non-Linear

b) Self Assessment x non Self Assessment

The contrast between the conditions is shown in the following figure.

	Linear	Non-Linear
Non-SA	20	20
SA	20	

Figure 31. Experimental design.

Each subject was required to go through the training package in one room, before completing the task in another room. The training took between half and three-quarters of an hour approximately, which was dependent upon the individual subject. The task took exactly half an hour. Subjects were required to complete the task on two separate occasions. Firstly they performed after the training as a measure of the amount of transfer, and then one week later to measure the degree to which they retained the training received.

3.2.1. Training Modules & Task

The task involved interacting with a simplified 'Process Control' plant. It required the subjects to monitor the plant status, respond to alarms, locate and reset faults through a set of hierarchically organized plant indicators. The training modules (as described in section 2.4.) were:

Orientation: Gathers subject data (age, sex), shows subject how to use the mouse to move objects on the screen, orientates the subject to the learning objectives, and demonstrates the principle of an information hierarchy.

Principles: Demonstrates the hierarchical nature of the indicators and processes.

Screen: Explains the functional area of the screen.

Keyboard: Shows the functions of the keys.

Monitor Output: Demonstrates how to monitor the overall system state.

Alarm: Demonstrates how to respond in the event of an alarm.

Delete: Demonstrates how to use the delete key.

Fault Finding: Demonstrates how to locate a fault through the hierarchy of indicators and reset the process.

Each of the training modules had a corresponding practice module, in which some interaction was required. In the case of 'Fault Finding' a screen based interactive simulator was used.

3.2.2. Experimental Conditions

The differences between the experimental conditions need further clarification and explanation. The conditions being: the control group (called both the 'Linear' condition and the 'Non-SA' condition), the Non-Linear condition, and finally the Self Assessment condition.

3.2.2.1. Control Condition

In the control condition, the training modules (as defined in 3.2.1.) were presented in a presequenced format. This sequence was as listed in section 3.2.1., this is illustrated in figure 32.

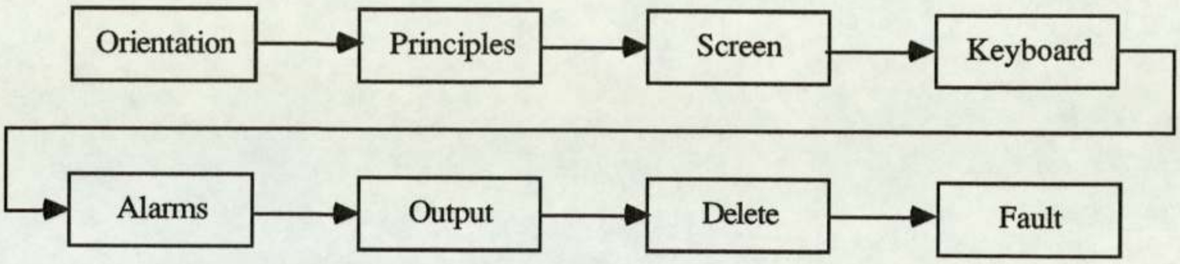


Figure 32. Format of modules in the control condition.

Subjects in this condition were allowed to repeat a module immediately they had completed it if they so wished, but were not allowed to go back over modules that they had previously completed. Further, they were required to view all of the modules and had no opportunity to finish prior to this point. In addition there was no form of extrinsic self assessment in this condition.

3.2.2.2. Non-Linear Condition

Subjects in the non-linear condition were able to freely select modules, and therefore determined their own order of presentation. The non-linear format is illustrated in figure 33.

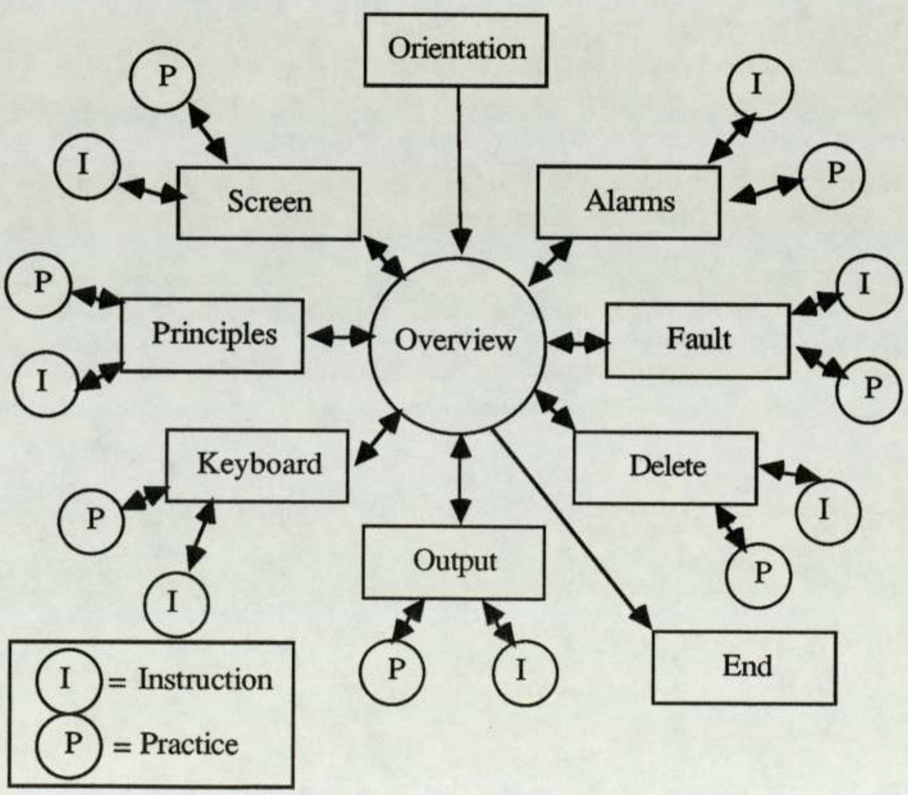


Figure 33. Format of modules in the non-linear condition.

These subjects were allowed to repeat modules, go back to any module they had previously selected, or choose not to select a particular module if they considered it was appropriate. Further they could leave the training at any point when they felt they they had developed the skills necessary to enable them to operate the transfer task effectively. Subjects in this condition used an overview screen which enabled them to select the next module appropriate to them. The overview screen is shown in figure 34.

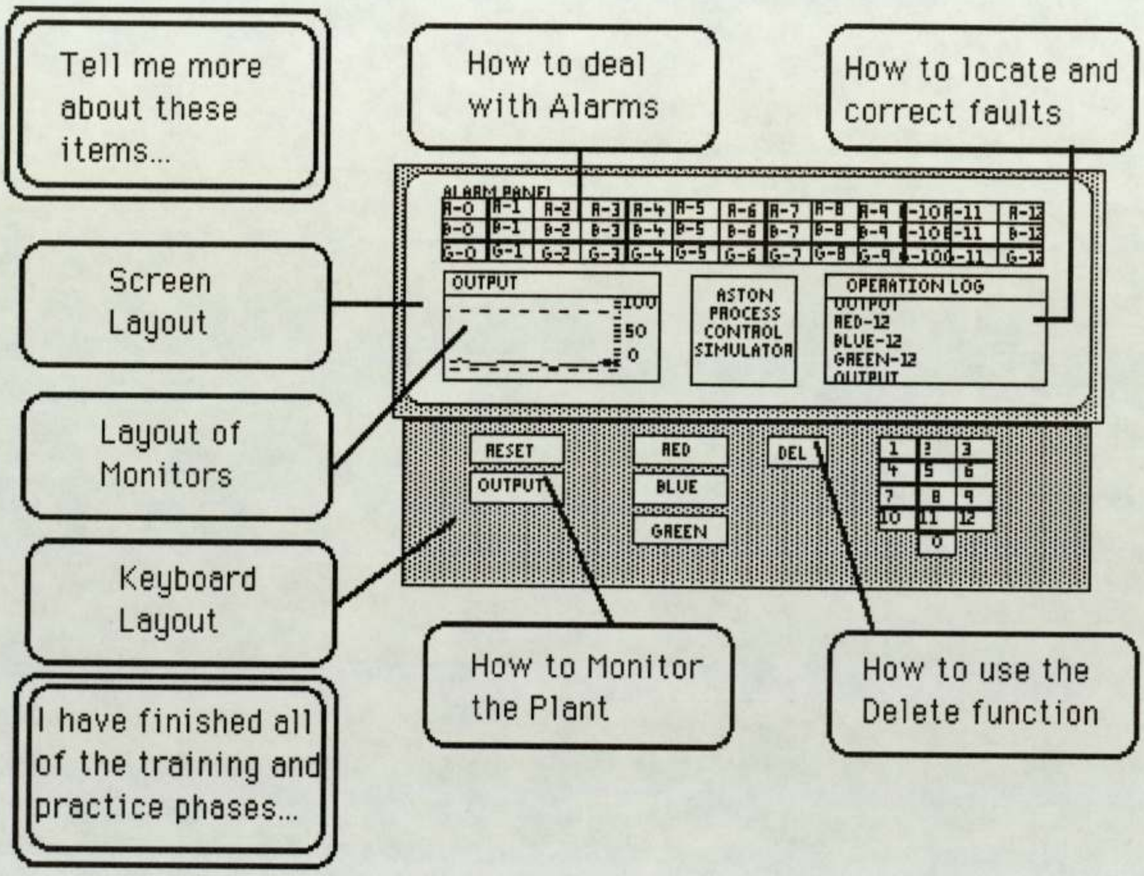


Figure 34. The overview screen.

To go to the next module, subjects had to move the cursor with the mouse to the text area that contained the information that they were interested in, and press the mouse button. This action took the subject to the choice of 'learn' or 'practice' as shown in figure 35.

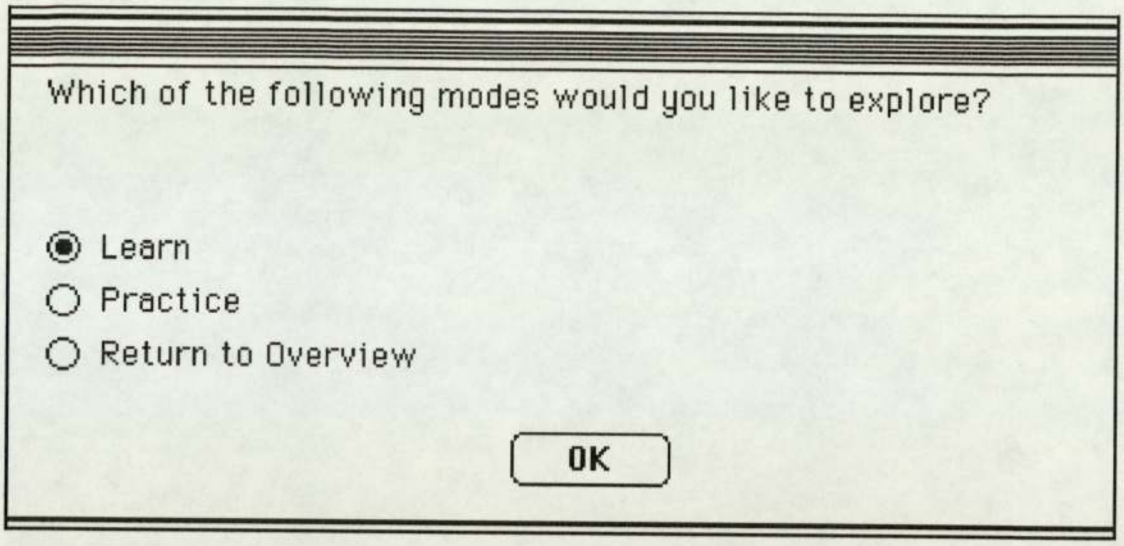


Figure 35. Learn, practice or return?

Subjects were required to click the cursor on the appropriate "radio" button, and then click on the OK button to move into their required module. After completing that module they were presented with the same choices again, this enabled them to repeat what they had done, move into a different mode, or return to the overview screen to start again.

3.2.2.3. Self Assessment Condition

The Self Assessment (SA) condition contained all of the modules, which were presented in a linear nature (see 3.2.2.1.). Subjects in the SA condition undertook SA at the end of the interaction in the practice module, but before they received feedback. The following figure shows the format.

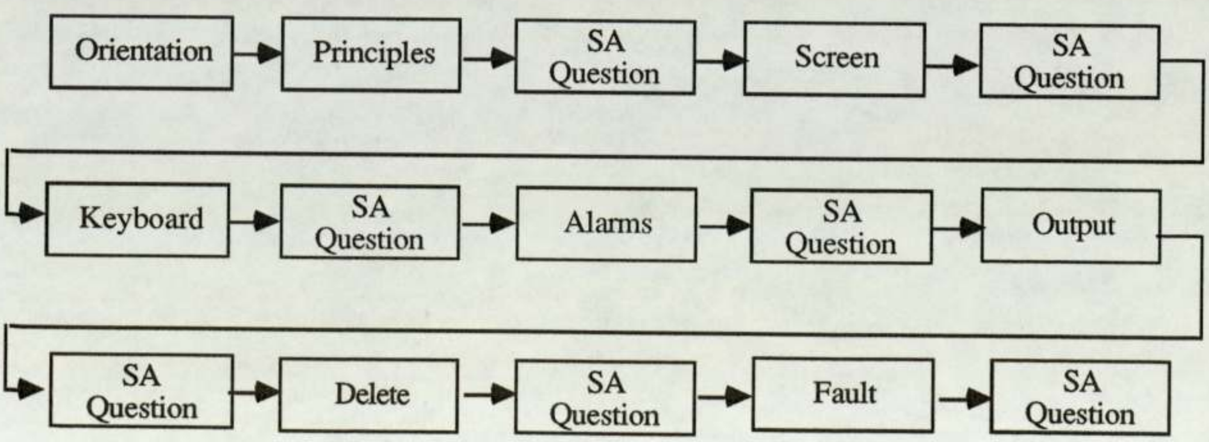


Figure 36. Format of modules in the self assessment condition.

In the SA condition, subjects were required to rate their 'confidence' in the correctness of their response. The questionnaire had a five point 'Likert-type' scale, with a range of responses from 'Very Unconfident' to 'Very Confident'. Figure 37 gives an example of the SA question. The SA question was presented to subjects after they had responded to a prompt, such as those illustrated in sections: 2.2.3., 2.2.5., 2.2.7., 2.2.9., 2.2.11., 2.2.13., and 2.2.15.

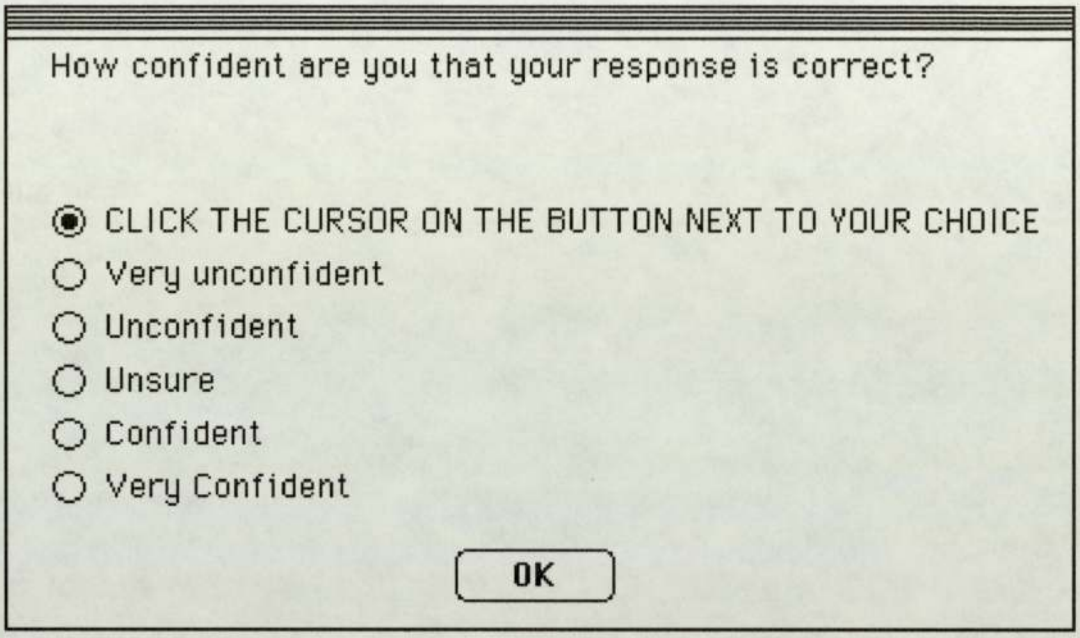


Figure 37. An example of the SA question.

After responding to the SA question, subjects were given feedback regarding their performance. Both of these factors were recorded for analysis.

3.3. PROCEDURE

The procedure for the investigation was as follows:

1. Subjects were given a demonstration of how to use the pointing device (mouse). This consisted of moving the mouse in the directions; north, south, east and west, with the accompanying explanation that these movements correspond to the movements of the pointer on the screen. It was further demonstrated that lifting the mouse off the mat (after dragging it to the edge and placing it down on the opposite side) allowed the subject to continue moving the pointer in the same direction. When the subjects confirmed that

they understood these concepts, it was explained that pressing the button at the top of the mouse enabled the selection of objects or choices. This was only possible after the pointer had first been placed over that object or selection.

2. The subjects were assigned to the experimental conditions (non-linear, linear, and self assessment) depending upon sex to ensure matched groups. At this point the numbers of subjects in each group were kept even, and the groups were matched for sex.

3. All subjects then answered a computer-based self confidence questionnaire (adapted from: Shrauger, 1982). This served two functions. First, it produced a measure of general self confidence for comparisons between the self assessment and non-self assessment conditions. Secondly, it provided subjects with the opportunity to become reasonably competent mouse users prior to the training session. Therefore all subjects were required to undertake the questionnaire (see appendix 4) even though the results may not have been used. This was to remove the advantage that the extra use of the mouse prior to training may have given.

4. Then subjects were required to undertake their assigned training condition on stand alone CBT courseware. The only instructions they were given by the experimenter were that:
   a) It was the effectiveness of the training material that was being measured
   b) All the data were confidential
   c) They could take as long as they required in order to learn the task
   d) When they had finished the training they should call the experimenter.

5. When subjects called the experimenter to notify that the training had finished, they were moved to another cubicle, and asked to control the 'process plant', (the transfer session). This was used to see how effectively the training had been in each of the experimental conditions.

6. Subjects were asked to complete a post-task questionnaire (see appendix 5 and 6). This was used to ascertain the subjects' opinion of the system and preferences for other media for instruction. Additionally in the non-linear condition, subjects reported on their strategy for sequencing the instruction and practice modules.

7. One week later subjects returned to run the task again, (the retention session). This was to test for differences in the retention of the material between the experimental conditions.

8. Subjects in the non-linear condition were required to undergo the Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971).

9. All of the subjects were paid £5.00 and thanked for their participation in the study. They were informed that the results of the study would be available by April 1989, and if they were interested they could be debriefed on the findings at that time.

3.4. EQUIPMENT

The majority of the investigation was computer based. The study made extensive use of computing technology in the design, implementation, and evaluation stages of the experiment.

3.4.1. Training Equipment

All of the training conditions utilised the same equipment. The training equipment can be divided into three sub-components; the hardware, the software and the environment.

3.4.1.1. Training Hardware

The training task was presented on computing hardware which consisted of a Macintosh™ SE microcomputer and Rodime™ 20 Mb hard disc. The subject interacted with the computer using a mouse.

3.4.1.2. Training Software

Hypercard™ was used to author, present and evaluate the self confidence questionnaire (see section 3.5.1.). The courseware was authored and presented on Coursebuilder™ a visual language system for computer based training (see section 2.3.2.). Hypercard was used for synthesis of the data. A special constructed program 'Course Report Analyser' was developed for this purpose (see appendix 7).

3.4.1.3. Training Environment

The training task was completed in a experimentation cubicle. The cubicle was specifically designed for the running of psychological experiments. It measures approximately 10' 11" by 8' 7", has black window blinds to cut out sunlight, and two overhead light bulbs controlled by a dimmer switch. The subject sat in a chair in front of a wooden table on which the microcomputer was placed. The layout is shown below.

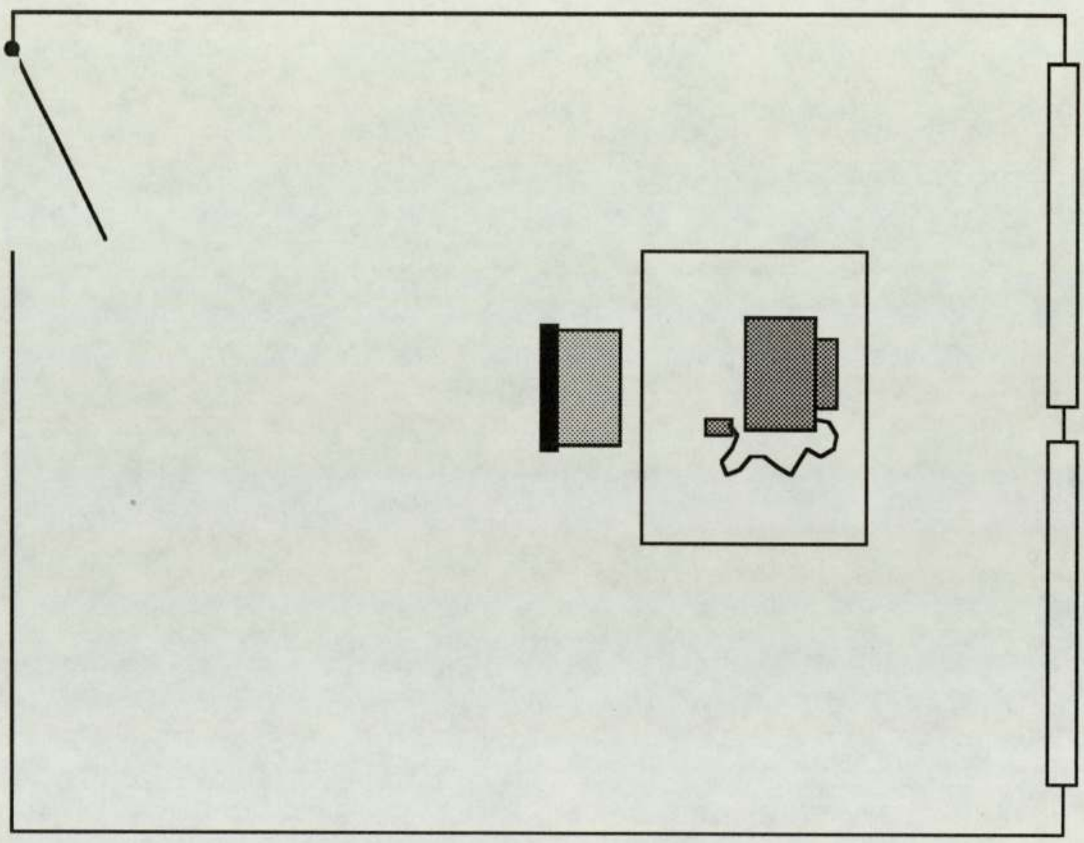


Figure 38. Training room layout.

3.4.2. Task Equipment

All of the conditions utilised the same equipment. The equipment can be divided into three sub-components; the hardware, the software and the environment.

3.4.2.1. Task Hardware

The abstracted 'process control' task was presented to the subjects on a RBG colour monitor using: a BBC Model B microcomputer, an Acorn 6205 second processor, and 40 track double disc drive (one drive was used to retrieve the data for the task, the second drive stored the subject data). Subjects interacted with the 'plant' via a purpose built dedicated keyboard.

3.4.2.2. Task Software

The software for the task was written in structured BBC Basic. For a fuller description of the software see section 2.1.2.2.

3.4.2.3. Task Environment

The transfer and retention task was completed in a similar experimental cubicle to that described in section 3.4.1.3.

3.4.4. Embedded Figures Test

The Embedded Figures Test (EFT) consists of two sets of cards. The first set have simple figures printed on them, whereas the second set have complex figures printed on them. The subject was timed, using a stopwatch, to assess their speed in finding the simple figure contained within the complex figure. The time data were then used to attribute a degree of field dependence to the subject. In the manual for the EFT (Witkin et al; 1971) it is claimed that the differentiation in perceptual functioning, as distinguished by the EFT, manifests itself in other areas of the individual's cognitive activity. The EFT is supposed to assess the ability to break up an organized visual field in order to keep part of it separate from that field. This is supposed to be an enduring mode of functioning. In terms of cognitive style, it proposes a dimension labelled field-dependence/independence. Field dependent persons tend to leave material 'as is' rather than imposing structure. Whereas field independent persons are likely to impose structure where it is lacking. It is further suggested that FI individuals can "perceive items as discrete from their backgrounds; or reorganise a field when the field is organised; or impose structure on a field, and so it is perceived as organised, when the field has relatively little inherent structure." It is postulated that these analytical and structuring abilities put forward by the dimensions of field dependency in terms of cognitive style are involved in a broader manner of functioning.

This is one measure of cognitive style on the dimension of field dependence. Field dependent subjects take longer to recognise simple figures embedded in more complex figures, whereas field independent subjects can recognise them much quicker. The test was used to look for any correlation between this measure of cognitive style and measures of subjects' strategy in the non-linear condition.

3.4.5. Post-Experiment Questionnaires

The post-experiment questionnaire was paper based. Subjects were required to answer the open questions (see appendix 5) regarding their opinions of the training medium, after completing the transfer task. In the non-linear condition more questions (see appendix 6) were asked to elicit the subjects rationale for their particular approach to the environment.

3.5. MEASUREMENT

Both the training task and the transfer task enabled the comprehensive recording of the subjects' interaction with the system. The training data were used for comparing the subjects' grasp of the ideas, concepts and procedures. The task data enabled a comparison of how well those ideas, concepts and procedures were put into practice. The task data were collected on two separate occasions, immediately after the training (transfer data) and one week later (retention data).

3.5.1. Self Confidence Questionnaire

Subjects in all conditions completed the self confidence questionnaire. This provided eight confidence factors (general confidence, public speaking, athleticism, social confidence, appearance, I.Q., mood, and personal worth). These factors were used for comparison of subjects overall confidence within the Self Assessment and non-SA conditions.

3.5.2. Training Time

The amount of time that subjects spent training was collected in terms of; overall time, time in individual instruction modules, and time in individual practice modules. The individual time had the potential to vary considerably, as each subject could proceed at their own pace, and repeat modules as required.

3.5.3. Number of Modules

The number and type of modules that subjects interacted with was recorded. This enabled a comparison of which modules were repeated as well as the total number of modules completed. In addition, it was also possible to investigate which modules were left out by subjects in the non-linear condition.

3.5.4. Order of Modules

Although the modules were presequenced in the linear condition, the non- linear condition allowed subjects to select the modules in any order. This order of selection was recorded for analysis.

3.5.5. Self Assessment

In the self assessment condition subjects were required to rate their confidence in a particular action, or sequence of actions, on a Likert-type five point scale. This rating was recorded for comparison with the action made.

3.5.6. Transfer and Retention Task

The abstracted 'process control' task provided the subjects with a goal task. Having completed the training, the subjects were required to control the 'plant'. Every key stroke subjects made was recorded, as was the overall status of the plant. This enabled the quality of the plant 'output' to be recorded as an index of the efficiency of the operator in dealing with plant deviations. This index of efficiency was recorded in both the transfer and retention sessions and used as a measure of the subjects' task performance.

3.5.7. Post Experiment Questionnaire

The questionnaire recorded subjects' opinions regarding the training environment. These opinions provided a basis for comparison between the conditions. For the non-linear condition, it also recorded the subjects' justifications for interacting in a particular manner. This information was used to identify sub-groups within this condition.

3.5.8. Embedded Figures Test

The embedded figures test (EFT) was used in the non-linear condition only. It provided a measure of cognitive style along the 'field-dependent/ independent' dimension. Subjects' response times for finding a simple figure embedded in a complex figure was recorded. The time data were used to identify field dependent and field independent subjects. The longer the subject took to find the figure, the more 'field dependent' they were considered to be, i.e. they are bound by the context of their environment, finding it difficult to see it as parts rather than a whole. Conversely, the quicker a subject took to find the simple figure the more 'field independent' they were considered to be, i.e. the less they are bound by the environment and are able to disassociate themselves from the context of the whole, seeing its as a collection of parts. Besides the time data the EFT it was also possible to collect data on the number of errors, stops, and the manner in which the complex figure is first described verbally to the experimenter.

4. RESULTS

Due to the extensive nature of the measurements taken, a considerable amount of analyses were performed. It was therefore decided that the results section would largely concentrate on the statistically significant findings. The results chapter presents these findings together with graphical interpretation.

4.1. INTRODUCTION

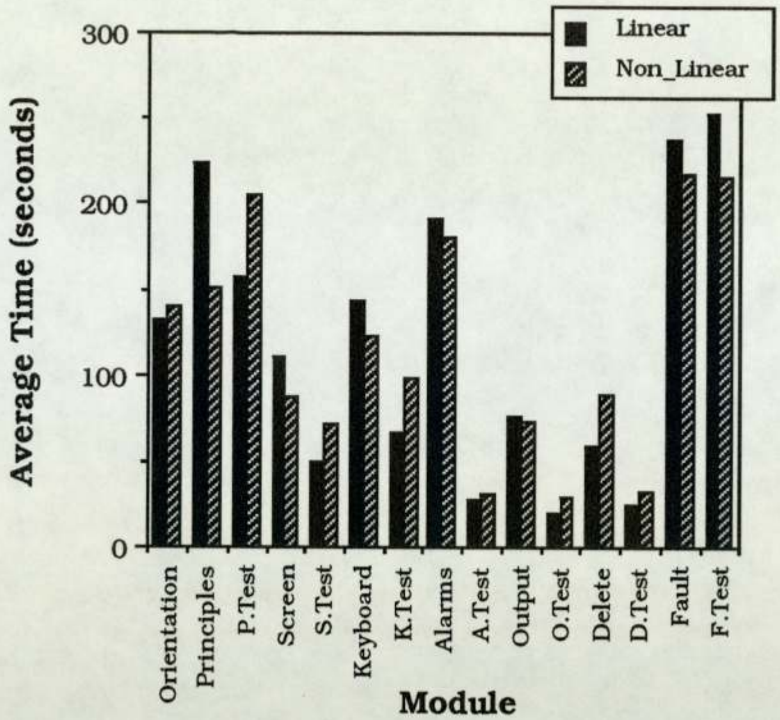
The three conditions under investigation in this research were: control (condition A, also called 'linear' and 'non self assessment'), non-linear (condition B), and self assessment (condition C). The data analysis was performed on three main areas; firstly a comparison of the linear and non-linear conditions, secondly a comparison of the learning strategies employed in the non-linear condition, and finally a comparison of the self assessment and non self assessment conditions. The analysis compared; training time, training modules, training performance, transfer and retention task performance, and the post-experiment questionnaire in all conditions. Additional analysis involved the results from the EFT in the non-linear condition, the self confidence questionnaire and self assessment question in the self assessment condition.

4.2. LINEAR & NON-LINEAR (AxB)

These conditions varied only on the linearity of their presentation. The linear condition presented all of the training modules in a fixed format whereas the non-linear condition allowed subjects to choose the order of presentation.

4.2.1. Training Time

The results showed that there was a difference between the conditions in overall training time and this was shown to be significant ($F_{1,38}$ $=11.122$, $p<0.002$). Graph 1 illustrates this finding between the the two conditions (linear and non-linear training). For fuller details of these findings consult appendix 9.



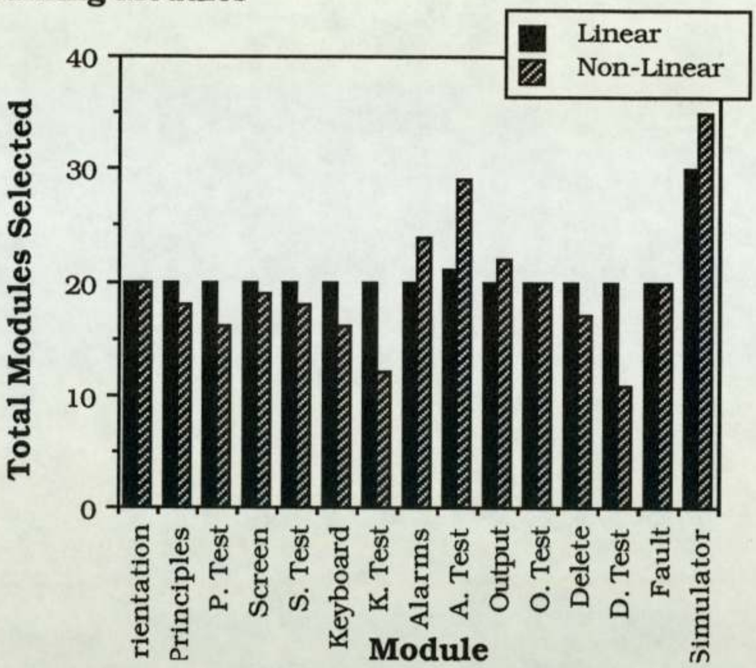
Graph1. Average module time in linear and non-linear conditions.

Further investigation revealed significant differences between some individual module times, as shown below:

Principles Instruction	$F_{1,38}=13.258$, $p<0.001$	(Linear took longer)
Screen Instruction	$F_{1,38}=6.634$, $p<0.014$	(Linear took longer)
Keyboard Instruction	$F_{1,38}=8.212$, $p<0.007$	(Linear took longer)
Alarms Practice	$F_{1,38}=7.788$, $p<0.008$	(Non-linear took longer)
Output Practice	$F_{1,38}=5.324$, $p<0.027$	(Non-linear took longer)

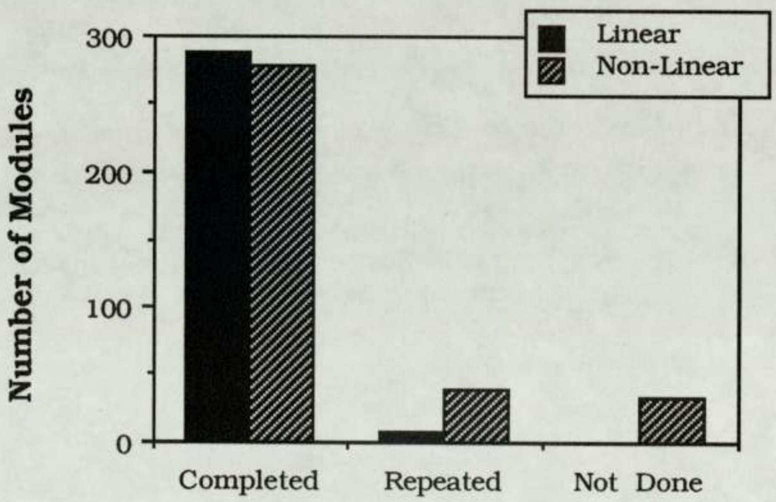
Graph 1 shows the average module time for each of the instruction and practice phases in both conditions.

4.2.2. Training Modules



Graph 2. Total modules selected in the linear and non-linear conditions.

Graph 2 shows the difference in the number of modules viewed in the two conditions, this approaches significance (Mann- Whitney U, $p<0.1$). For fuller details of these findings consult appendix 9.



Graph 3. Total number of modules completed, repeated and not attempted in the linear and non-linear conditions.

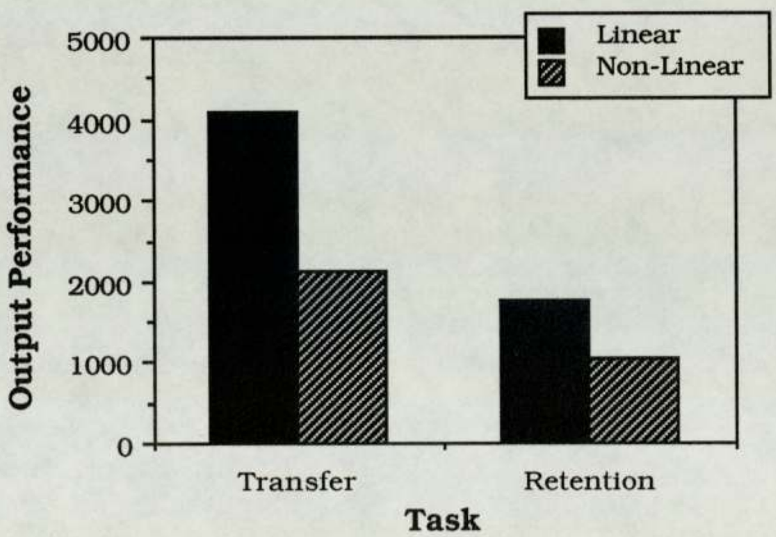
Some subjects in the non-linear condition repeated significantly more modules than the linear condition (Mann-Whitney U, $p<0.01$). This is illustrated in graph 3. As a group, the non-linear condition also chose not to complete all of the modules (Mann-Whitney U, $p<0.01$) whereas the linear condition were not given this option. For fuller details of these findings consult appendix 9.

4.2.3. Practice Performance

There was no overall significant difference in the training performance between the two conditions. The most variation was in the training simulator, but this was not significant (see appendix 9)

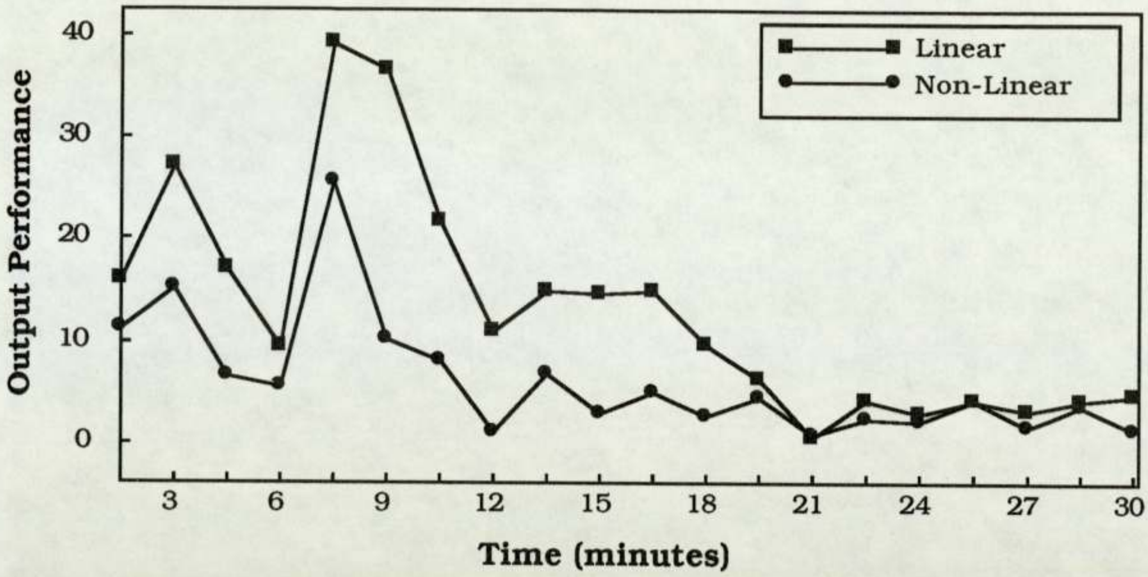
4.2.4. Transfer & Retention Task Performance

The difference between the transfer performance for the two conditions was significant, ($F_{1,38}=4.71$, $p<0.04$), with improved operational performance in the non-linear condition. Similarly, operational performance in the retention task for the non-linear condition was better than that in the linear condition ($F_{1,38}=4.791$, $p<0.04$). Both groups performance improved significantly from the transfer task to the retention task ($F_{1,38}=17.082$, $p<0.0002$) as is shown in graph 4.



Graph 4. Transfer and retention performance in the linear and non-linear conditions.

A fuller analysis of the transfer performance, over the task duration of 30 minutes, in the two conditions reveals a highly significant difference ($F_{1,19}=2.588$, $p<0.0002$). As graph 5 illustrates, this difference remains until approximately half way through the session.

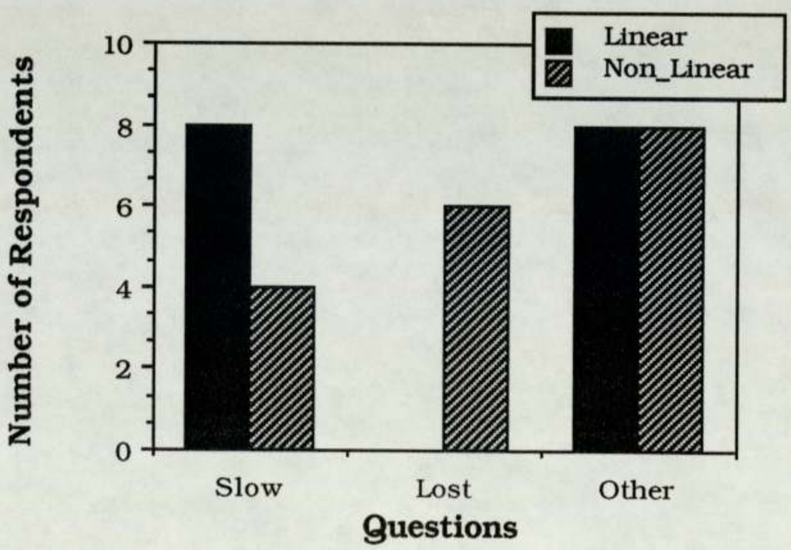


Graph 5. Transfer task performance of the linear and non-linear conditions.

For fuller details of these findings consult appendix 9.

4.2.5. Post-Experiment Questionnaire

None of the subjects in the linear condition reported getting lost in the navigation between modules, whilst six subjects in the non-linear condition reported this.



Graph 6. Post-Experiment Questionnaire.

Eight subjects in the linear condition complained that the system had a slow response time, whereas only four complained of this phenomenon in the non-linear condition. The numbers of subjects who would have preferred the training to be accompanied by, or replaced by, a demonstration on the actual equipment was the same (eight in both conditions). These findings are represented in graph 6.

4.2.6. Summary

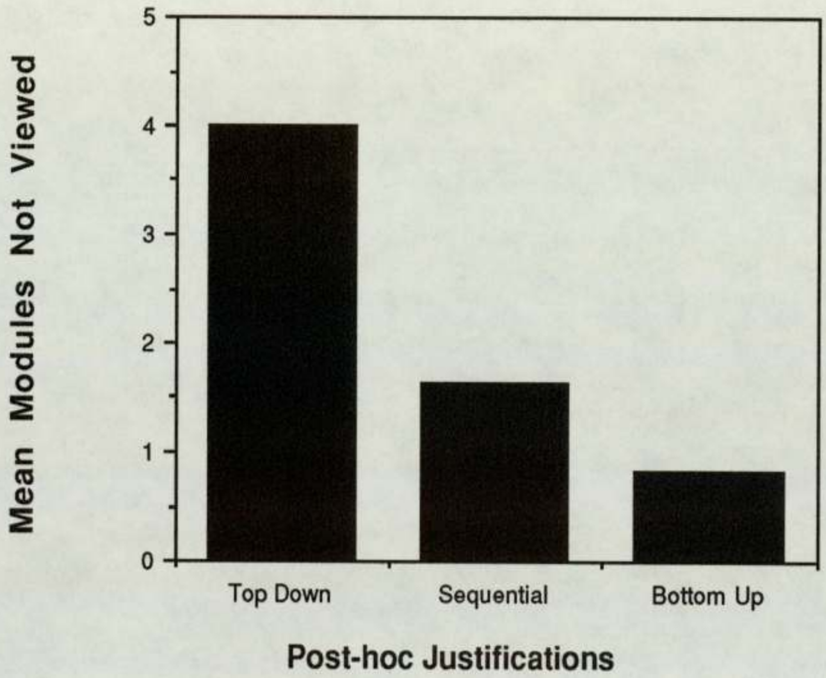
The difference in training time for some of the individual modules between the conditions was significant. Subjects in the linear condition took longer in the initial instructional modules, whilst subjects in the non-linear condition took longer in some practice modules. Although subjects in the non-linear condition completed less modules overall, they repeated more of these modules they accessed compared with the linear condition. Subjects in the non-linear condition performed significantly better than the linear condition on the initial transfer task. Both groups performance improved significantly on their retention task. As a result of the different modes of training, twice as many linear subjects reported dissatisfaction with the system response time. This is even though there were reports of non-linear subjects becoming lost within the relatively simple network. In summary, there were differences in training behaviour between the two conditions and differences in initial transfer performance.

4.3. LEARNING STRATEGY (B)

Learning strategy data was examined in a number of ways. Firstly subjects in the non-linear condition were divided into groups based upon their self reported justifications for their learning strategy. Subjects were then divided into groups based upon the EFT scores. Finally they were divided into groups based upon their order of selecting modules to view. Each of these sub-divisions were analysed in turn against the data obtained on; training time, training modules, task performance, EFT scores and the post experiment questionnaire. Only the significant findings are reported (for futher details see appendix 10).

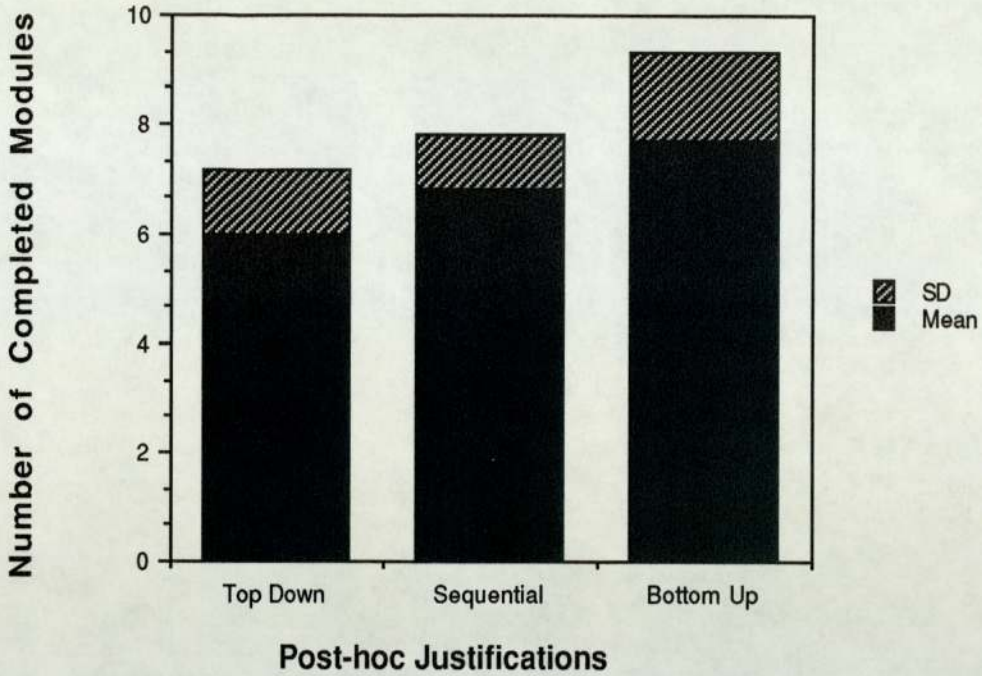
4.3.1. Post-hoc Justifications

Subjects were classified according to their reported learning style, for example; "I looked at the most important things first" (Top Down, n=6), "I progressed from more basic information upwards" (Bottom Up, n=6), and "I went through the modules in an anticlockwise sequence from the overview screen" (Sequential, n=8). The number of modules viewed was then related to the subjects' reported learning style. A significant difference was found between the Top down and Bottom Up groups with regard to the number of modules omitted, (Mann-Whitney U, $p<0.02$). Graph 7 illustrates this point.



Graph 7. Post-hoc groups and mean modules not viewed.

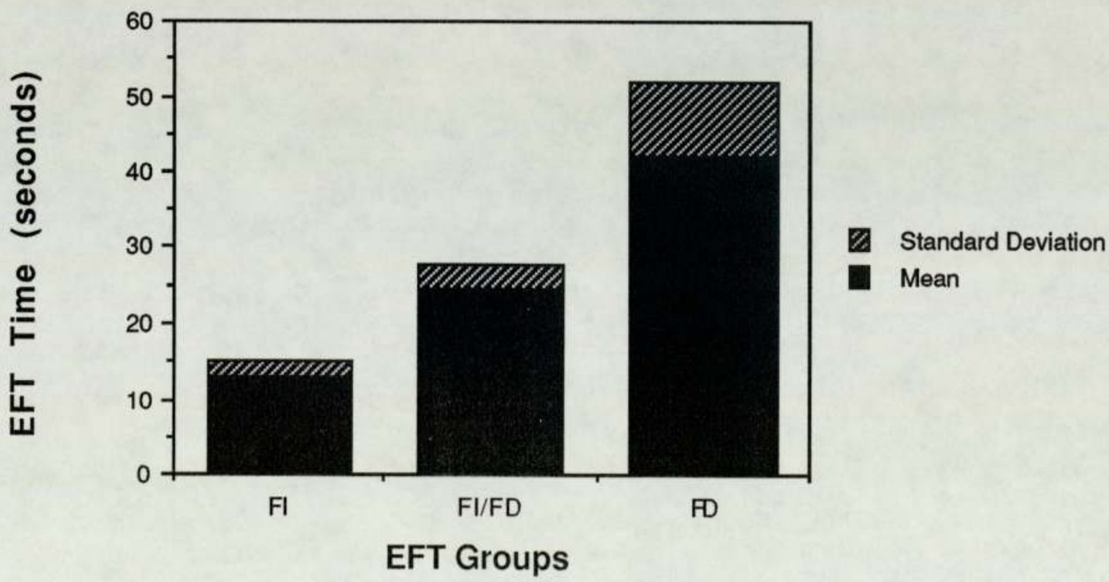
A significant difference was also found between the Top Down Group and the Bottom Up group for the number of modules completed, (Mann-Whitney U, $p<0.01$), as shown in graph 8.



Graph 8. Number of modules completed in the post-hoc groups.

4.3.2. Embedded Figures Test

The only significance difference found was between the groups' of EFT



Graph 9. EFT groups and mean time to solution.

scores ($F_{2,17}$ =37.646, p<0.0001). The EFT groups were formed from the times to find embedded figures which provided a measure of field dependence. The groups were; Field Independent (n=6), Field Independent/Dependent (n=8, a mid-way category) and Field Dependant (n=6). The mean scores of these groups are shown in graph 9.

4.3.3. Observed Strategy

For analysis of the subjects strategy, the training modules were arranged in a hierarchy of complexity. This hierarchy is shown on figure 39 with the most complex module at the top, and the simplest module at the bottom.

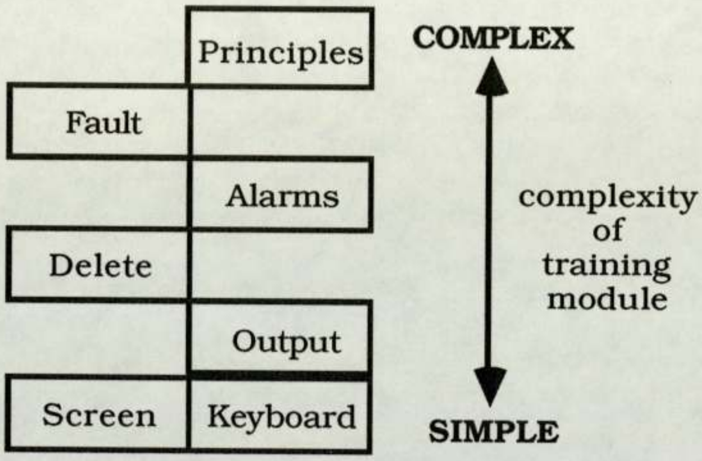


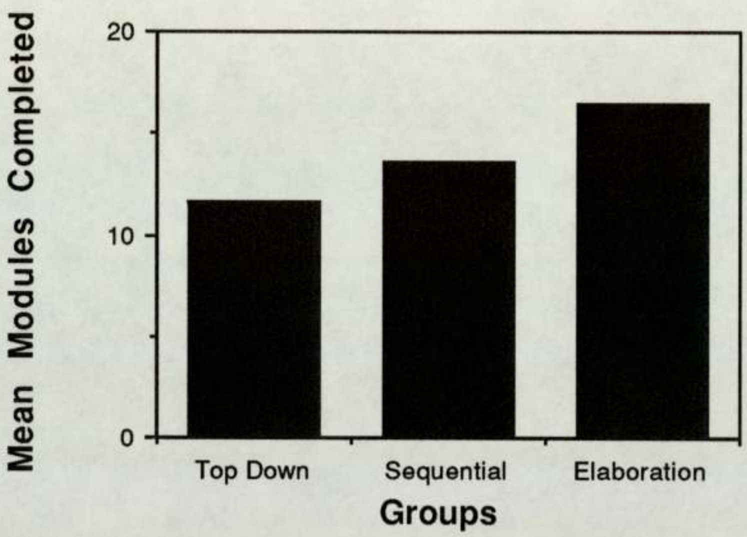
Figure 39. Hierarchical representation of modules.

The subjects were divided into groups based upon the order that they visited modules in their navigation around the non-linear training environment. Three groups emerged which contained similar characteristics.

The Top Down group (n=6) emerged as being exactly the same subjects as the Top Down group in the post-hoc justification analysis. Their strategy was defined as a sequence of accessing the training modules from the higher-order procedures at the start, and accessing the lower-order procedures towards the end. This can be defined as a 'complex to simple' strategy. The next group to emerge was classified as employing a Sequential (n=9) strategy. The members of this group were not exactly the same as the Sequential category in the post-hoc justifications analysis. Their strategy was defined as accessing the modules in either a clockwise or anticlockwise manner following the layout of the overview screen. Once the route was completed they may have gone back to some of the modules for repeats. The final category to emerge was a new one, this was called the Elaborative (n=5) strategy. The Elaborative strategy was defined as a 'zigzag' approach, moving from higher modules to lower ones, and then back up to higher modules. It was presumed that this was a form of elaboration. The data was analysed based upon these three categories.

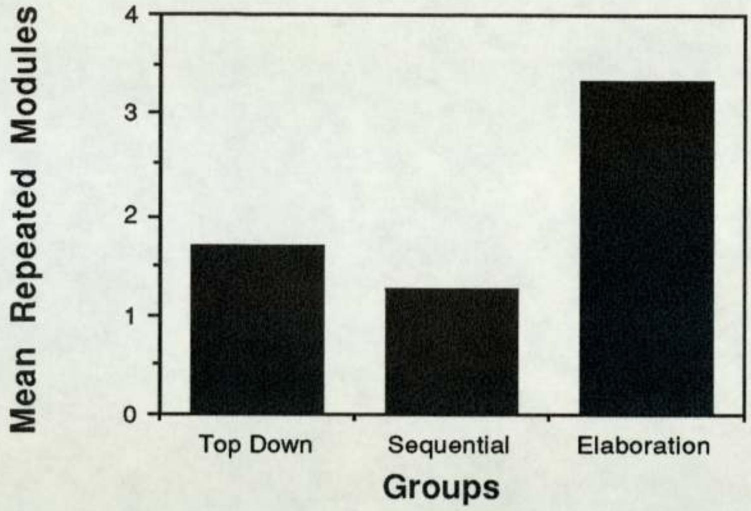
4.3.3.1. Training Modules

There was a significant difference between all three groups for the mean number of modules completed (Mann-Whitney U, p<0.01), as illustrated in graph 10.



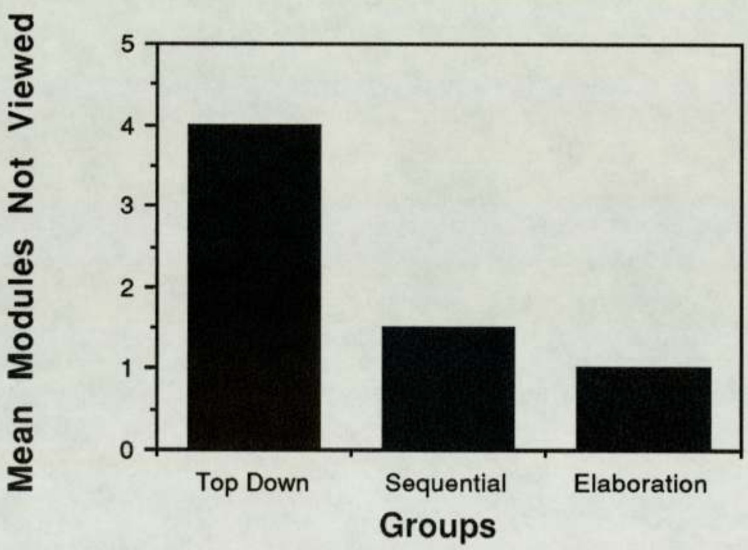
Graph 10. Mean modules completed in observed strategy groups.

There was also a significant difference between the Sequential and Elaborative groups on the number of modules repeated (Mann-Whitney U, p<0.05). This is shown in the graph 11.



Graph 11. Mean modules repeated in observed strategy groups.

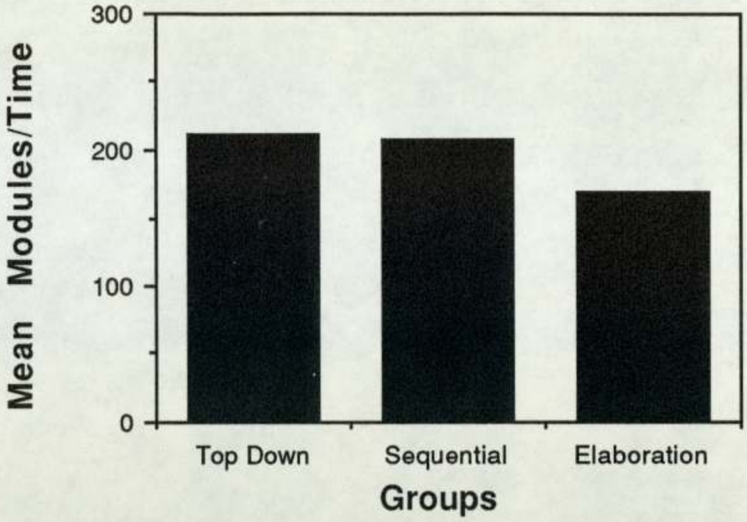
Subjects in the Top Down group accessed significantly less modules than subjects in the other two groups (Mann-Whitney U, $p<0.05$) as demonstrated in the graph 12 below.



Graph 12. Mean modules not viewed in observed strategy groups.

4.3.3.2. Training Time

Subjects in the Elaborative group spent, on average, less time in each module compared to the other two groups ($F_{2,17}=7.609$, $p<0.005$). This is shown in the graph 13.



Graph 13. Mean module time in observed strategy groups.

4.3.3.3. Summary

From the results it appears the 'Observed Strategy' analysis accounts for the most variation in subject behaviour within the non-linear condition. Significant differences were found in the number of modules completed, repeated, not viewed, and the average time spent in training modules. Therefore the groups; Top Down, Sequential and Elaborative were adopted in preference to the other analysis groups for further discussion. It should be noted that there was no significant difference between overall training time and transfer task performance in the three groups.

4.4. SELF ASSESSMENT & CONTROL (AxC)

The difference between these two groups was that in the self assessment condition a self assessment question was presented after the subjects' response to a training task, but before feedback to that response. In all other respects the conditions were the same.

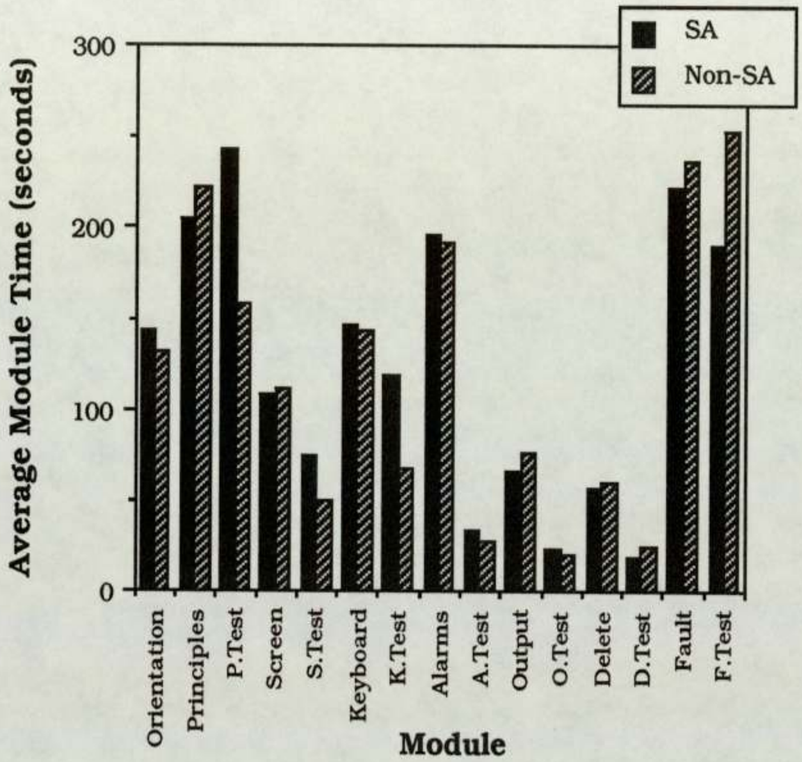
4.4.1. Training Time

The results show that there was a significant difference in training time between the two groups overall ($F_{1,14}$ =2.107, p<0.01). Further exploration shows that there was a significant difference in three of the practice modules when the time to administer the SA component was removed.

These were:

Principles Practice	$F_{1,39}$ =4.943 p<0.032	(SA took longer)
Keyboard Practice	$F_{1,39}$ =6.328, p<0.016	(SA took longer)
Delete Practice	$F_{1,39}$ =13.001, p<0.001	(nonSA took longer)

There was no significant difference in any of the other instruction or practice modules. Graph 14 illustrates these points further.

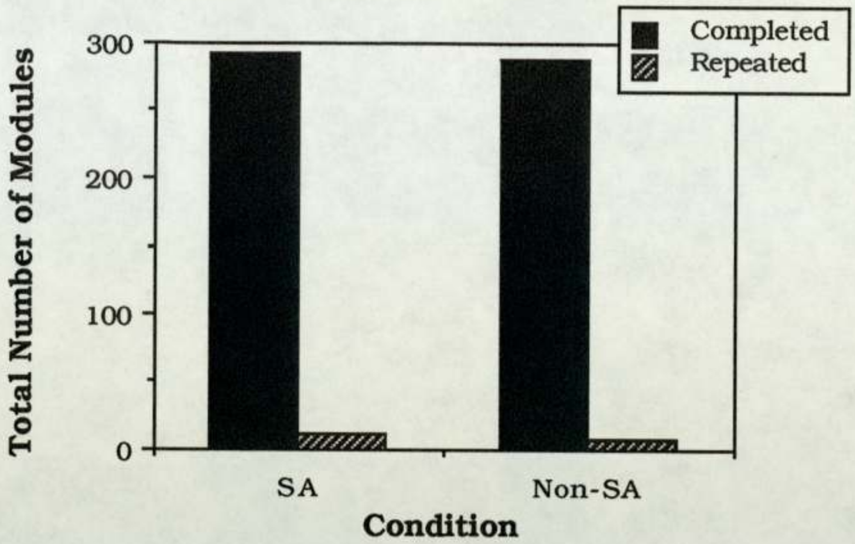


Graph 14. Average module time for the SA and nonSA conditions.

Visual examination of the graph suggests that the SA condition subjects take longer for the first half of the training but end up being quicker.

4.4.2. Training Modules

The difference in the number of training modules completed and repeated was not significant, as shown in the graph 15.



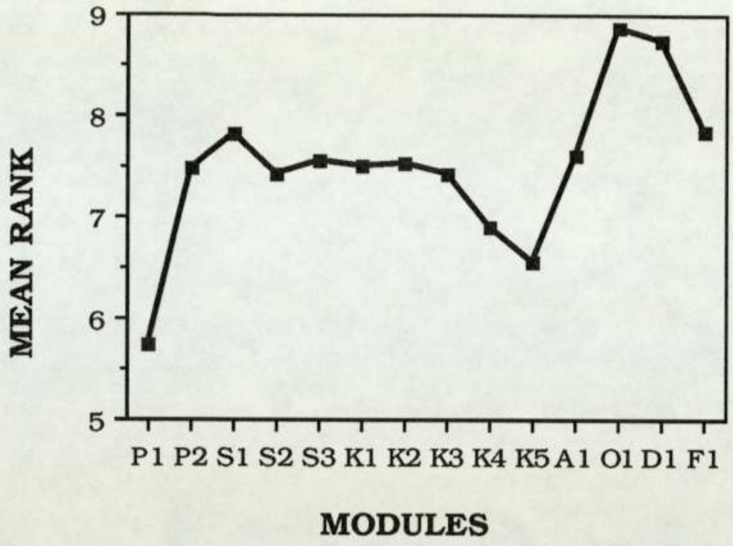
Graph 15. Total modules completed and repeated in SA and nonSA conditions.

4.4.3. Training Performance

The performance of subjects in the two conditions was not significantly different (see appendix 11).

4.4.4. Self Assessment Question

Analysis of the self assessment responses against the practice modules using Friedman 2 way ANOVA showed no significant differences (see appendix 11). However there does appear to be a general trend for confidence to improve over the training session as shown in graph 16, but this is not conclusive.

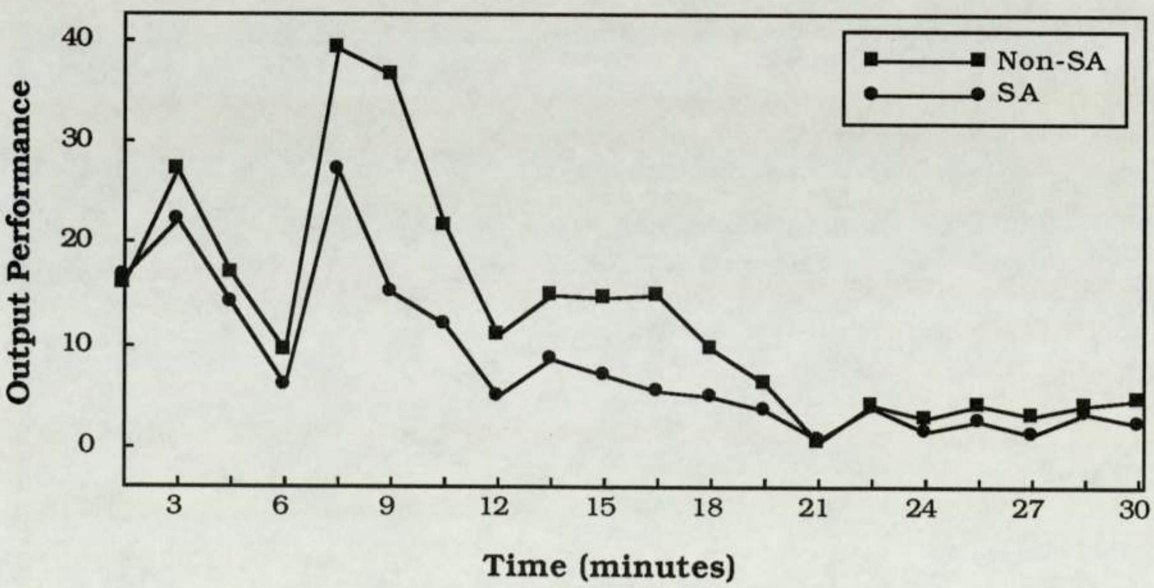


Graph 16. Mean rank for the SA question in the practice modules.

Further details about these results are available in appendix 11.

4.4.5. Transfer & Retention Task Performance

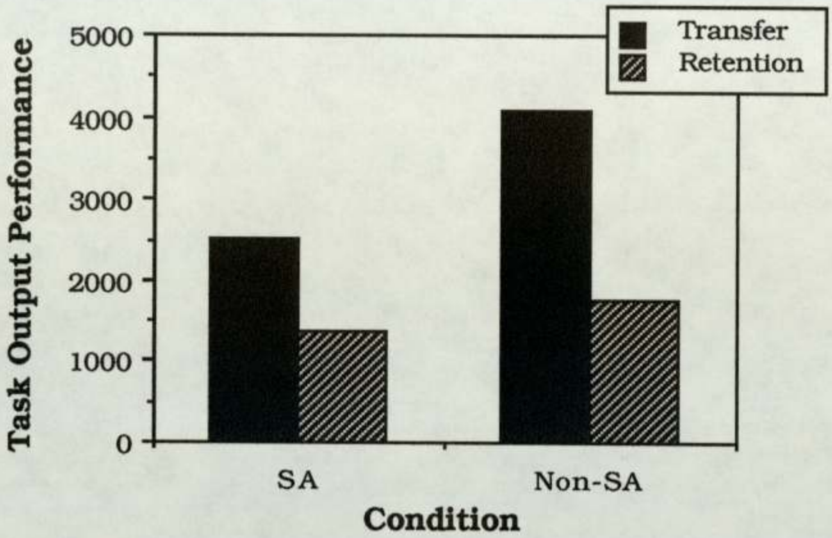
Analysis of transfer task performance taken every 1.5 minutes over a 30 minute session reveals that the difference between the SA group's and the non-SA group's performance approaches



Graph 17. Performance in the transfer task taken every 1.5 minutes.

significance at 7.5 minutes ($F_{1,38} = 3.121$, $p < 0.085$) and 16.5 minutes ($F_{1,38} = 3.120$, $p < 0.085$). This is further illustrated by graph 17, where the higher score on the scale 'output performance' means the worse the subjects' performance. These differences were only marginal and did not last for long.

There was a significant improvement in performance in both conditions between the transfer and retention sessions ($F_{1,38} = 15.177$, $p < 0.0004$). This is further illustrated in the graph 18.

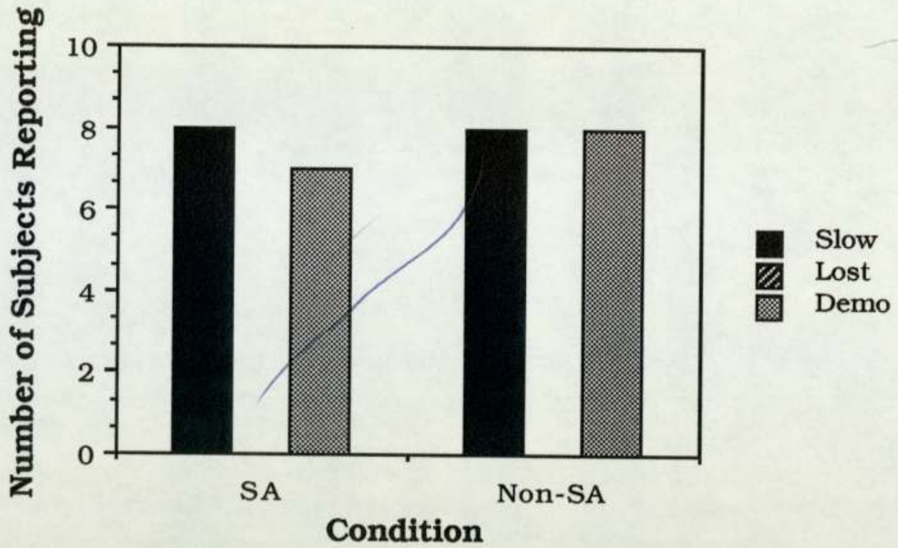


Graph 18. Transfer and retention performance in the SA and nonSA conditions.

Graph 18 illustrates that although the SA condition initially had marginally improved performance in the transfer task (as indicated by a lower score on the task output scale), this does not re-appear in the retention task.

4.4.6. Post-Experiment Questionnaire

As graph 19 illustrates, the subject opinion questionnaire showed no real differences between the two conditions in attitude towards the system as measured by the questionnaire. In both conditions eight subjects reported that they thought the system too slow in places. None of the subjects became lost in the system. Finally, seven subjects in the SA condition and eight subjects in the nonSA condition would have preferred the training to have been accompanied by a demonstration of the full system in addition to the training received.



Graph 19. Subjects opinion questionnaire.

4.4.7. Self Confidence Questionnaire

No significant differences were found on any of the following scales of the self confidence questionnaire between the two conditions:

- General Confidence
- Public Speaking
- Athleticism
- Social Confidence
- Appearence
- I.Q.
- Mood
- Personal Worth

Full details on the raw scores and the analysis can be seen in appendix 11.

4.4.8. Summary

Training in the SA condition took longer in the initial modules, but SA subjects became quicker towards the end of the training. There was no significant difference in the overall number of training modules. Subjects in the SA condition showed a marginal improvement in transfer performance, but this effect was soon diminished. Although the self assessment questions were not significantly different between the practice modules, the general trend was an increase in confidence through the training session. Finally there was no significant difference in the self confidence questionnaire scores between the two conditions.

4.5. RESULTS SUMMARY

The general findings of the results section are threefold. First there was an improvement of the non-linear condition over the linear condition with respect to transfer performance. Secondly, a variety of strategies were observed within the non-linear condition, each being equally effective in producing the improved transfer performance. Thirdly, self assessment made a marginal difference in training and transfer, but this effect quickly diminished.

5. DISCUSSION

This chapter is split into three parts. The first contrasts linear and non-linear training environments. Under this heading the issues discussed are why the two environments may lead subjects to interact in a different manner, and what implications this may have for future design of training systems. The second part concentrates solely on non-linear environments, and parallels are drawn from research in hypermedia. The last part examines the self assessment aspect of the study. Much of the literature is derived from educational studies.

5.1. INTRODUCTION

In the last chapter the analysis was carried out in three distinct parts, namely; linearity of training, non-linear environments and self assessment. These sections remain separate for this discussion. The structure of this chapter will be: first to consider the findings based on the subjects training behaviour and transfer task performance, then the wider implications before summarising the whole section.

5.2. LINEARITY OF TRAINING

The first section of the results (section 4.2.) compared linear and non-linear training modules. The analysis focused on the behaviour of subjects during the training phases, and on subsequent transfer performance on the task. The training materials were identical in the two conditions, except that in the non-linear condition subjects were allowed to choose the order of presentation, and had the freedom not to access modules if they so wished. In contrast, the linear condition subjects had to go through all the training modules. These were in a predetermined order, selected to be the optimum, based on previous experience of training subjects on this task.

5.2.1. Training and Transfer Analysis

Analysis of the results produced statistically significant findings. These will be considered in two parts, first the training performance and secondly the transfer performance.

5.2.1.1. Training Performance

Analysis of the results showed that there was a significant difference in the training times between the two conditions (section 4.2.1.). It appears that subjects in the linear condition took longer in the initial instruction phases (Principles, Screen and Keyboard) than subjects in the non-linear condition. This could be because the order of modules not being appropriate for all subjects in the linear condition. The non-linear subjects could choose their own order. However, it is also likely that as these were the first three instruction phases undertaken by the linear subjects, they were becoming acclimatised to the training environment and getting to grips with understanding the task that had been set. Whereas subjects in the non-linear condition started at many different points in the course, so this effect did not show itself. This conjecture is supported by the fact there were no significant difference between the time spent in orientation for both conditions.

The total number of modules completed by both groups was not significantly different. However, the non-linear subjects showed more variation in the number of modules they accessed and repeated (as shown in section 4.2.2.). Non-linear subjects repeated significantly more modules, and accessed significantly less than the linear group. Subjects in the linear condition were given the opportunity to repeat any module directly after completion of that module. The only module that any of the linear subjects chose to repeat was the last practice module (called Simulator or F.Test). It could be argued that linear subjects felt no need to repeat a module directly after completion as its contents would still be well remembered.

Although the non-linear subjects repeated significantly more modules but, completed in total about the same overall number, some chose not to access all of the modules. The opportunity to do this was also one of the major differences between the two conditions, and the linear subjects were not afforded this option. Despite the differences in training behaviour between the two groups there was no significant difference in the overall performance in the practice modules (section 4.2.3.). The greatest degree of difference was in the practice module Simulator, but this still was not significant.

5.2.1.2. Transfer Performance

Subjects in the non-linear condition showed significantly better transfer performance than the linear subjects, as measured by the 'output' of the task simulator (section 4.2.4.). Closer analysis showed that this improvement in transfer performance lasted until approximately half way through the transfer task session, at which point the performance between the two conditions was no longer significantly different. Why this difference was found is a matter for speculation. It may be that subjects in the non-linear condition were able to assimilate the information in a manner that best suited them. This resulted in better initial transfer, but the margin was diminished as the session continued. One explanation for the reduction of the difference between the transfer performance in the two conditions, is that through interaction with the task equipment, all subjects were able to enrich their knowledge regarding how to perform effectively within the system.

The results also showed that both conditions improved significantly from their transfer to retention sessions. At the end point of the transfer session, subjects had maximised their competence in performance on the system. Graph 4 shows that the improvement in performance between the two sessions for the linear condition was very marked, whereas the improvement for the non-linear condition was not so marked.

5.2.1.3. Subject Opinion Survey

Graph 6 in section 4.2.5. shows that there were subjective differences between the two conditions. Twice as many subjects in the linear condition reported dissatisfaction with the speed of the training system at some point. This could be due to the linear subjects being required to go through all the training that was put before them. This could have led to a feeling of not being in control, whereas the non-linear subjects had control over what they saw and were, therefore less likely to report dissatisfaction. This was presumably because they assumed responsibility for what was displayed. Being more in control of the presentation of learning material can have drawbacks. Whilst no subjects reported getting lost in the system in the linear condition, there were some reports of this phenomenon in the non-linear condition. Being responsible for their own guidance means that the subjects had to remember where they had been, what their plans were (if any), and what their purpose was for being at a particular point. A lapse in any of these memory reliant factors could result in the subject becoming lost (albeit temporarily) in the system.

5.2.1.4. Summary

From the results it appears that presenting the training modules in a way that allows subjects to sequence the order themselves leads to improved task performance, at least initially. The time spent in training may not necessarily be quicker, it will just be spent differently. More training modules were repeated, and some subjects chose not to access some modules altogether. There were also different subjective reactions, which may have been related to the degree of control the subjects felt they had.

5.2.2. Related Issues

The implications of the findings can be taken a stage further and be reviewed in the light of published work that can be related to this research: individual differences, locus of control, self directed learning, exploration & discovery, mental models, transfer of training and human computer interaction. Within these major outlines other related topics may be considered.

5.2.2.1. Individual Differences

Individual differences are often the most problematic area, and are an issue at the core of understanding human behaviour. Usually the search is for commonality within groups of individuals (and this research is no different). If any attention is paid to individual differences it is normally to the extent of assaying, isolating and accommodating differences (Egan & Gomez; 1985). Computer based training has been going down this road since it began. Typically the trainee is led down one pathway, only allowed minor detours from this path, and is required to return to the main path reasonably quickly. The principle of ensuring that all trainees encounter exactly the same material is probably due to the concern that they should reach a desired standard of competence within a reasonable amount of time. This is probably coupled with a desire to feel in control of what trainees see and the order in which they see it. This presupposes that trainees are not capable of making the decision themselves and that there is a single correct order. Whilst it is true that in order to make the decision to see one part of the course before the other it is necessary to know what each part of the course consist of and how it all fits together, this can be overcome by giving a brief overview of each module. This research demonstrates that training individuals in this way may be more effective than other, more traditional, approaches.

A non-linear approach to training allows the individual trainees to adapt the material to suit their own needs. Four general categories of individual differences that relate to learning have been suggested:

- Abilities
- Cognitive Style
- Prior Knowledge
- Affect/Motivation (from Brooks, Simutis & O'Neil; 1985)

These will be dealt with in more detail in section 5.3. However it is clear that the subjects in the non-linear condition are more able to adapt their material to suit these individual differences than linear subjects.

5.2.2.2. Locus of Control

The idea that the locus of control might have an influence on performance is not new. Annett (1976, a) cites Anderson (1976) as reporting a study in which students either followed or did not follow routing instructions through modules. Locus of control was determined as the extent to which the students felt responsible for their own progress (internal) or the system was responsible (external). The results indicated that students who perceived an internal locus of control performed better than students who perceived an external locus of control. The results from the present study also show this. Subjects in the linear condition could be presumed to perceive an external locus of control, whilst non-linear subjects are more likely to perceive locus of control as internal. Further indications have been presented which suggest that more efficient training resulted when the student was allowed to control the instruction (Mager & Clarke; 1969). Mager & Clarke report other studies in which it was demonstrated that training time was reduced and the trainees more able as a result of student control. Both of these reports support the findings in this investigation, that providing subjects with control over the sequence of their training modules improves their performance, although the physical nature of the environment was quite different.

Issues relating to locus of control, choice, and autonomy need to consider the trainees ability to assume responsibility to manage their own learning. (Hartley; 1985). This issue is considered next.

5.2.2.3. Self Directed Learning

Carver & Dickinson (1981) define a self directed learner as one who is able to accept and retain responsibility for their own learning. It is their claim that this is an attitude, rather than a skill, suggesting that by placing learners in the appropriate environment, they will learn to become self directed. Similarly Dickinson (1981, a) claims that learner centred methodologies create an individualistic learning environment making the learner autonomous in taking on the responsibility for their own learning. This responsibility relates to the management of the environment and the decision making that is involved. Although these authors were referring to teaching English language in the classroom, their assertions are just as applicable to this investigation. In the non-linear environment, subjects were given total management of their learning, the choice of which modules they accessed, and in which order. Decisions to select a particular module may have been made as part of a planned strategy, or spontaneously based upon previous interactions. Dickenson (1981, a) proposes that self directed learning is desirable mainly because it improves learning efficiency. More specifically, developmental self directed learning can transfer to other situations (Perry & Downs; 1985). It also allows students to adopt their own preferred strategies for aspects of the learning process (more will be said on this in section 5.3), and finally it may facilitate a more effective learning environment. The linear condition however is unlikely to foster these advantages, because subjects only have control over the pace of the material and the opportunity to repeat the previous module.

Dickinson (1981, b) attempts to define the extent of self directed learning (SDL) along the dimensions of :

- Aims
- Method
- Pace
- Place
- Materials
- Monitoring
- Assessment

Referring to these dimensions, the non-linear condition in this investigation is clearly not completely self directed, but there is complete autonomy on some of the dimensions, see figure 40.

S.D.L.. Dimensions	**Linear**	**Non-Linear**	**Self Assessment**
Aims	Directed	Directed	Directed
Method	Directed	Autonomy	Directed
Pace	Autonomy	Autonomy	Autonomy
Place	Directed	Directed	Directed
Materials	Directed	Directed	Directed
Monitoring	Directed	Autonomy	Directed
Assessment	Directed	Directed	Autonomy

Figure 40. SDL dimensions for the experimental conditions.

The figure 40 does not give the complete picture of the true nature of the differences between the conditions. For instance, although the aims and assessment were directed to some extent in the non-linear condition, the subjects themselves could choose not to follow those aims, and choose not to be assessed if they did not go into the practice modules. Self assessment is another dimension of SDL and is covered in section 5.4. Despite the obvious advantages of SDL it may be that this type of environment may not suit everyone. Some individuals may dislike the ambiguity of a self directed environment and prefer to be led through the training materials. Issues relating to this are discussed in section 5.3. As Dickinson (1981, b) suggests, free choice may include the option to relinquish autonomy at any point, and return to it at will. This option was not provided for in this particular investigation.

5.2.2.4. Exploration & Discovery

Linked to the notion of SDL is the type of environment that encourages exploration by the student. The linear environment does not allow for any kind of exploration, as the subjects' direction was controlled by the presequenced order of the training modules. However the non-linear environment was open-ended in this respect, requiring the subject to initiate an action to access a training module of their choosing. The non- linear environment was constructed in a manner that should support exploration (Wendel & Frese; 1987). This was by inclusion of the following features; task orientation, modularity, structure, an overview, and error correction. Ferm, Kindborg & Kollerbaur (1987) further insist that if an environment is to stimulate exploratory learning it must allow the students make their own decisions and all functions of the system must be immediately accessible. The non-linear condition seems to fulfil these criteria also. Wendel & Frese report that encouraging exploration leads to better performance, more exploration, and higher satisfaction. This investigation certainly supports the first of these findings. With regard to the second, a different type of behaviour was observed to that in the linear condition. Twice as many subjects in the linear condition reported being dissatisfied with the response time as the training system. However there were reports of non-linear subjects becoming lost in the 'exploratory' environment which could be considered dissatisfactory. Therefore both environments had potential drawbacks.

Whilst it seems intuitively true that an exploratory environment may lead to better learning, thought must be given as to why this is so. Hartley (1981) points out that discovery learning places an emphasis on the control that learners have in building up their own cognitive structures. However, Hartley adds a note of caution suggesting that learners in this type of environment may not make a good appraisal of their own abilities or requirements, and therefore may not make effective decisions. This observation has to be tempered with the fact that the investigation reported in this thesis was comparing training environments of a modular format with some level of direction (see figure 33) and was not therefore a completely free learning situation as may be found in some classroom studies. Hartley (1981) further reported that techniques for facilitating learner control in CBT were not well advanced and that most recommendations include showing the student the content structure. To some extent this position has changed with the advent of hypertext systems (to be discussed further in section 5.3.).

5.2.2.5. Mental Models

SDL suggests that learners build up their own structures of how the information is linked. The building of intellectual structures is reminiscent of Piagetian learning which proposes that learners learn how to acquire knowledge and become more active and self directed. The Piagetian approach (in contrast to programmed learning) finds it acceptable to make mistakes as part of the learning process. This is the view that learning is a natural (cognitive) process (Papert, 1980). Through the use of the overview screen in the non-linear condition an explicit map of the modules was provided for the subjects to interact with and develop their own structures and networks of how these elements link together. The use of networks and spatial learning strategies is advocated by Patrick et al (1986) especially for encouraging learners to develop their own network maps.

The notion of mental models proposes that the purpose of the training is to install the correct 'model' of the task in the learners cognitive structures. Norman (1986) distinguishes between three aspects of mental models with regard to system design. These are; the design model, the system image and the user's model. It is clear to see that the users model may be quite different from the design model through translation and contamination in the design process. In the words of Norman, "the system image is critical". This observation can be related to the design of CBT (see figure 41).

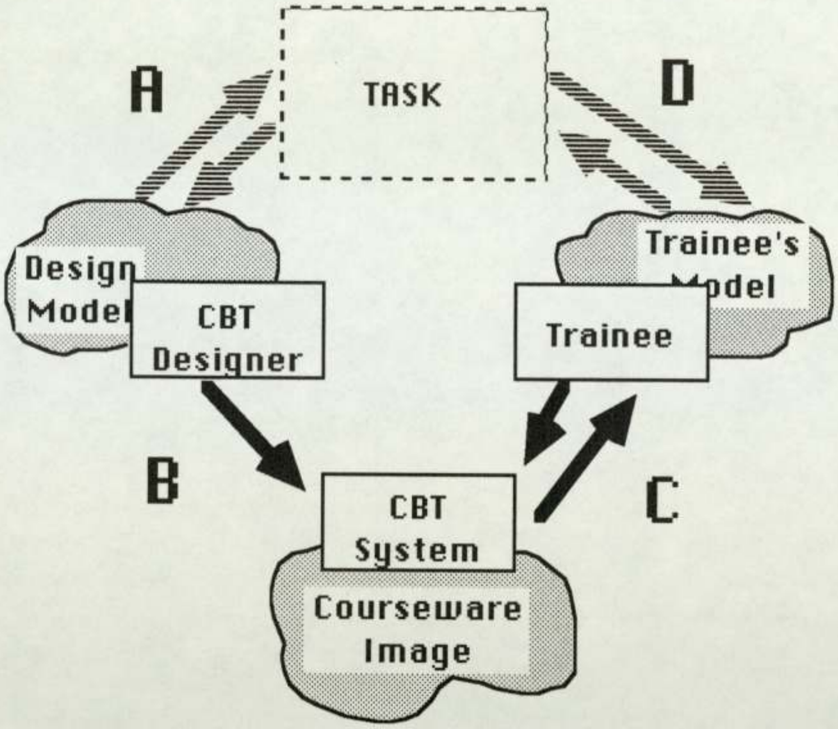


Figure 41. Four aspects of mental models (adapted from Norman, 1986).

In the figure above it is proposed that there are four aspects of mental models with respect to training. These are: the task to be trained, the designers model, the courseware image, and the trainees model. This is different from Norman's model as it includes the additional aspect of 'courseware image'. In the first instance the CBT designer has to build up a model of the task which may be through interaction with it, or by observing the task being performed. Phase A as denoted by the figure is a critical part in the design process. If the data about the task is collected through third party methods the designer has to be certain that no part of the task has been left out or misrepresented. There are obviously limits to the depth of detail that can be sought, but in practical terms the designer has to be convinced that at least the most important data on the task has been collected before it can be analysed and translated into training modules. The designer's model will include a model of the task, a model of the trainee and how to impart the first on the second. Phase B is concerned with the construction of the courseware based upon this model. CBT is often a 'cleaned up' version of the task, simplifying the elements to be trained. These may be broken down into modules concerned with imparting specific procedures. From this emanate the courseware image of the task to be trained.

Designers do not often have direct contact with the trainees, so they are relying on the CBT to impart the essential elements of the task. In phase C trainees are learning the 'ideal' procedures under optimum conditions. This is most likely to be a rather sterile presentation of the task, as it may not be appropriate to build in unforeseen, infrequent or unusual events, particularly early on in the training programme. In order for the user to build up a realistic model of the system, the four aspects of the mental models should be as close as possible. However, in the final phase (D) the trainee continues to build up the model of the system through interaction. Under real time operational conditions the true nature of the system reveals itself, and a more realistic model of the task is built. In the research reported here, improvement in operational performance was shown in all conditions over time. This supports the notion that the trainee's model continues to be developed past the formal training stage. The real task may contain unforeseen or unusual events that it would not be reasonable to contain in the training program due to time constraints, and the infrequency of their occurrence. By including such items it may misrepresent the true day to-day nature of the task.

5.2.2.6. Transfer of Training

Transfer of training is the degree to which the skills that have been learned transfer to the task performance. The results show that in the non-linear condition transfer was significantly better than the linear condition. Perhaps this effect can be better understood if the factors that promote transfer are considered. Transfer can be promoted by several factors including the meaningfulness and appropriateness of training materials, and the abilities and motivation of trainees (Annett & Sparrow; 1985). Meaningfulness of the training was maintained in both conditions by the goal directed nature of the modules in which direct procedural actions were shown, and graphically displayed. The non-linear condition had a discovery element, to the extent that subjects could choose what to access next. This self directed nature of the condition could also promote transfer by encouraging learning to learn. The degree of control the subjects had over the training environment could also increase the intrinsic interest of the task, motivating the learners to a greater extent. This could be a self-feeding situation, the more the subjects exert control, the more interest is found and the more motivating the task. The non-linear condition had another factor in its favour, it allowed individuals of differing levels of ability to adapt the training materials to suit their own needs. For instance, if an individual did not need to go to the bottom level of the course to examine the basic functions of the keyboard, there was no requirement to do so. However if another individual was of novice ability and wished to start from the very basic functions, then they could. Overall this suggests that the non-linear environment may have had more of the features that promote transfer than the linear environment.

5.2.2.7. Interaction

The nature of the interaction of subjects with the material in the non-linear condition was different to subjects in the linear environment. Subjects in the non-linear condition were given the opportunity to form, or not form, a strategy for accessing the training modules. In contrast the linear subjects had to accept the training module in the presequenced order, and build up their model of the task as they received the information. In the non-linear condition subjects were able to build up their own model of the system through accessing the training modules in an order that was meaningful and appropriate to them. The individual interacts with the environment to produce an outcome in terms of changes in understanding and performance. This new knowledge will determine how learners subsequently interact with the training environment, more specifically which module is chosen, or not chosen, to view or review. This interaction is represented in figure 42.

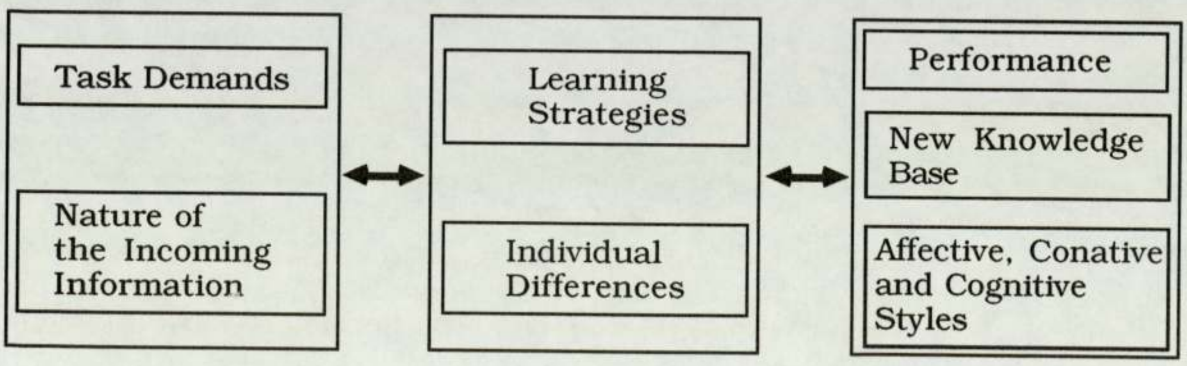


Figure 42. A schematic representation of a learning strategies framework (adapted from Brooks, Simutis & O'Neil; 1985).

5.2.2.8. Other Explanations

Despite the positive explanations put forward to explain why the non-linear condition appears to be superior to the linear condition, there are alternative explanations. It is possible that the linear subjects were suffering greater fatigue by the end of the training course than the non-linear subjects, although in terms of absolute training time there is very little difference. If fatigue is the explanation, it must be asked 'why should their improvement in the transfer task be so dramatic?' Another possibility is that of linear subjects were suffering from goal prevention, being forced through modules in an inappropriate manner. This however supports the case for non-linear training, as it would allow subjects to go back and review any course component at any stage within the course. Another criticism may be sample size. Twenty subjects to each condition may be considered a relatively small sample from which to make bold assumptions. The postulations put forward are indications of what may be causing the differences in behaviour, more research is necessary before more can be claimed. However, work in this area has been continuing for at least two decades and seems to put forward a strong case for learner centred control in CBT.

5.2.4. Summary

The results appear to have demonstrated that the non-linear environment provided the learner with an adaptable training environment. The subjects in this condition showed that they were able to learn the task more quickly than subjects in the linear condition. Although there was no significant difference in training performance (as measured by the practice tasks) it does appear from the results that providing the learner with control over the training modules led to improved transfer performance. This effect is in spite of non-linear subjects having the additional task of managing their learning as well as learning the task. It is suggested that this essential difference between the two conditions is possibly the major reason for better performance.

Subjects in the non-linear condition were required to assume responsibility for their own learning, navigating around the modules, deciding what should be next, and deciding when the learning had finished. This most likely led them to perceive an internal locus of control and behave in a self directed manner. They are also likely to have approached the ordering of the modules in a manner that was appropriate to their understanding the nature of the task. This would lead to 'building up' or 'filling in' the cognitive structures as deemed appropriate. This could have enhanced the quality of transfer to the task they were required to perform after training. In contrast the linear subjects had a much reduced management function, only being able to choose to repeat the last module they viewed. This is likely to have led to them perceiving an external locus of control and behaving in a more passive manner. In addition, because they had no control over the ordering of the training modules, the structuring of the task may have been forced upon them, and not as they would have preferred, if allowed the freedom to choose. However, this model of the subject assumes that they seek control, and are able to structure relatively unstructured material.

In summary, it appears that the hypothesis was supported. Providing learners with control over the sequence of training modules did result in better transfer task performance. The most likely reasons for this were discussed. It is interesting to note that practice performance within the training modules was no better in the non-linear condition than in the linear condition. This suggests that it is not the training per se that made the difference, but the way it was delivered to the subject.

5.3. NON-LINEAR ENVIRONMENT

The subjects' behaviour in the non-linear condition was analysed further (section 4.3.) to examine the styles and strategies that were employed to manage the training environment. As was mentioned in section 5.2. the non-linear environment provides the opportunity for subjects to interact with the training environment in an individual manner. This also gives the investigator the possibility of recording this information for analysis, and investigating the notions of style and strategy.

5.3.1. Training Behaviour & Transfer Performance

Due to the large amount of data that was considered, attention was directed mainly on the statistically significant findings. The findings were split into three parts. First the analysis relating to the training behaviour is considered in relation to the styles and strategies employed. Secondly the transfer performance is considered. Finally, these sections are brought together and summarised.

5.3.1.1. Training Behaviour

The results analysed the behaviour in three ways. Firstly by asking subjects what they thought they were doing (post-hoc justifications), secondly by measuring cognitive style along the field dependence dimension using the Embedded Figures Test, and thirdly by analysis of the subjects observable strategy. Interpretation of the results will be considered in these three categories.

5.3.1.1.1. Post-hoc justifications

By grouping subjects based upon their own post-hoc justifications (or rationalisations) for their behaviour, it was possible to investigate the degree of behavioural differences in the training session. As graph 7 shows, the top down group viewed significantly less modules than the bottom up group (definitions are given to these groups in section 4.3.1.). This is probably because the top down approach led subjects to work from higher-order down to lower-order modules (see figure 39). This meant that they were able to make greater inferences about the content of the lower-order modules, and therefore there was less of a requirement to access them. In contrast the subjects working in a bottom up manner were not able to make the same type of inference about the content of higher order modules, and therefore were likely to complete more modules than the top down group. This was confirmed in the results (see graph 8). These were the only significant findings for all of the analyses on the post-hoc justification groups.

5.3.1.1.2. Field Dependence

The subjects in the non-linear condition were split into groups based on their degree of field dependence as a dimension of cognitive style. The EFT has been cited as a reliable measure in other research (see section 5.3.2.4.). A highly significant difference was demonstrated between the three groups (see graph 9) along the dimension of field dependence. However, there was no statistical difference between the three groups for any of the training behaviour measures taken.

5.3.1.1.3. Observed Strategy

The subjects in the non-linear condition were also split into groups based upon an experimenter observation of the strategies employed (a fuller explanation is given in section 4.3.3.). It was interesting to note that the subjects in the top down group remain the same in both the post-hoc justifications analysis and the observed strategy analysis. This suggests that what they actually did was what they thought they were doing. However this is not entirely true for the other two groups. Some subjects in the sequential and elaborative groups were different to the other two proposed groups in the post-hoc justifications analysis. This suggests that individuals may think that they are behaving in a particular manner, or planned to behave in a particular way, but end up interacting differently with the environment. It is also probable that the justifications were attempts at a rationalisation of their behaviour, but then it would be expected that they would be more accurate (these issues are discussed further in section 5.3.2.1.).

The results show that there was a significant difference between the three groups in the mean number of modules completed (see graph 10). The elaborative group probably completed more modules because they are continually elaborating on items of interest and relevance in an almost random manner. On the other hand, the sequential subjects go through the modules in a more controlled form, following the layout of the overview screen and accessing fewer modules. The top down group access the least number of modules probably for the same reasons discussed in section 5.3.1.1.1. Graph 11 shows that subjects in the elaborative group repeat significantly more modules than subjects in the sequential group. This may be due to the elaborative strategy employing a zigzag pattern (moving from higher to lower and back again) therefore repeating more modules to see how they fit in to the whole picture. Sequential subjects however, follow a more linear line of accessing the modules. It may also be possible that the non-linear line of investigation is more prone to random accessing of modules which leads to the repeating of more modules.

The top down group chose to access significantly less modules than the sequential and elaborative groups (see graph 12). This is most probably due to the same reasons given before, that they are able to make inferences about the content of the lower modules and therefore feel that they do not need to access them. The final significant finding was that the elaborative group spend significantly less time on average in each of the training modules than the other two groups, as shown in graph 13. The reason for this is probably because elaborative subjects repeat more modules and therefore spend less time in each module. However because they spend less time in each module they are required to repeat more.

5.3.1.2. Transfer Performance

Despite the variations in training behaviour there were no significant differences in the transfer task performance between the three groups. This suggests that the non-linear environment allowed individuals to interact and select the modules in a manner of their own choosing, which resulted in an optimum format for their own purposes. The subjects' strategies, although different, were the most appropriate and natural for that individual. This maximised the transferability of the training modules to the task that had been trained for.

5.3.1.3. Summary

From the results it is clear that the groups formed by the observed strategy analysis account for the most variation in subjects' training behaviour. Although subjects in the three groups (top down , sequential and elaborative) interacted in quite different manners, this did not lead to any significant difference in transfer performance. This finding suggests that each strategy adopted was probably the most natural one for the individual. This promoted transfer, which was significantly better than that found in the linear condition. It was suggested however that some of the subjects in the non-linear condition may have preferred more directed training, such as the linear condition provided. For instance the sequential subjects required an external cue to provide a structure to the non-linear condition, whereas the top down group were able to rely on an internalised strategy. It is proposed that the elaborative group also relied upon external cues for the next module given to them by the content of the module that they were currently within.

Taken individually the strategies were quite different. The top down group impose their own structure on the otherwise relatively unstructured environment, to good effect as the results indicate. It is proposed that these subjects are able to deal with the ambiguity of the situation effectively and are able to structure it. Subjects in the sequential group however use the overview screen to provide structure, they appear unable to impose their own, and are possibly concerned that they may forget where they have been if a less explicitly structured approach is taken. It is possible that these subjects may have preferred to have been in a linear training environment, with a predetermined sequence of modules, relieving them of the management function. The elaborative subjects appear to be acting spontaneously (or with situated actions, see section 5.3.2.1.) in what outwardly appears to be a moving around the modules in a random sequence. Although it is supposed that this behaviour is intended to be structured, as a random strategy was not reported. It is proposed that subjects are linking modules that are important to building up their individual learning structures, filling in gaps in their knowledge. It may be that this particular approach is rather inefficient, but this is a problem related to the environment. In order to make effective choices of module to enter, it is necessary to have a global knowledge of what is contained within each module (discussed further in section 5.3.2.3.). This was provided for to some extent with the overview screen which informed subjects briefly of the content of each module. However it was reported that this facility was not used very often.

5.3.2. Related Issues

The interpretation of the findings is complex and there is no simple cause/ effect relationship. The non-linear environment appears to be different to the linear environment in many ways, some of these will be considered further.

5.3.2.1. Intentions, Goals, Plans & Actions

The non linear condition allowed subjects to interact with the training modules in a freer manner than the linear subjects. It is necessary therefore to consider the intentions, plans, and goals of subjects. Assuming that the subjects' goals were to operate the task simulator (it should be noted that from previous experience the majority of experimental subjects are extremely highly motivated, being in a novel situation, and very eager to please) current thinking on cognition would assume that they formulate some sort of plan to extract information from the system. Whilst the behaviour of the top down and sequential subjects appears to fit neatly into this idea of plans, actions and goals, the behaviour of the elaborative subjects is a little harder to explain. A more likely explanation is provided by Suchman (1987) and is called 'situated actions' and by Norman (1988) termed 'opportunistic actions'. Both suggest that purposeful behaviour may be ad-hoc, rather than following a preplanned series of steps, depending upon the human's intelligent adaptation to fluctuating circumstances. Norman proposes 'seven stages of action' as an approximate model, but still recognises the interaction and perceived feedback as the essential part in the sequence. These seven stages of action are:

- Forming the goal
- Forming the intention
- Specifying the action
- Executing the action
- Perceiving the action
- Perceiving the state of the world
- Interpreting the state of the world
- Evaluating the outcome

(from: Norman, 1988).

The seven stages consist of one goal stage, three execution stages and three evaluation stages.

Norman gives an example to highlight the interactive nature of people and their environment, showing that goals can be achieved even when the actions change quite dramatically in response to changes in the environment. Consider the goal of switching on a light. An action sequence of getting up and walking over to the switch may already be initiated, but if someone enters the room at that moment and you ask them to hit the switch for you, your goal has been achieved through different actions than originally planned. Through this example, Norman is attempting to demonstrate that behaviour is adaptive, accepting that plans may only be a framework within which to operate, and that humans have the flexibility to alter or change completely from the original course of action. Suchman accepts the notion of plans as frameworks, proposing that individuals adapt their course of action depending upon the situation and circumstance. These factors are fluid, and therefore so is human behaviour. Norman agrees, proposing that a continuous feedback loop exists, the results of which direct further goals and subgoals. Both Suchman and Norman propose that 'situated actions' and 'opportunistic actions' respectively are adaptive behaviour in response to situations.

The non-linear environment did allow subjects to interact with the material in an ad-hoc manner if they so wished. This may explain why the bottom up groups' post-hoc justifications did not reflect the true manner of their interactions. The actual behaviour being different from the plan. The top down groups' post-hoc justifications on the other hand were very accurate. This could be either the result of a plan being carried out, or the reporting after the event giving the impression of a plan. The subjects could really be reporting a rationalisation of their situated actions. The reality is likely to be a hybrid of both approaches, incorporating a loose planned framework. The actual amount of planning involved will depend upon degree to which the individual is familiar with the environment (the coherence of their mental model and effectiveness of their navigational strategy), time available, and amount of self-direction the individual is motivated to assert, together with the amount of change occurring in the environment. It would be much easier to plan and execute that plan explicitly in a static environment, but an ever changing environment (whether cognitive, such as learning, or physical) increases the likelihood of situated actions.

If the cognitive structures of the individual are changing with new incoming information, as is reasonable to suppose in a learning environment, then the individuals are most likely to be continually revising their plan of what it is they need to see next. This type of behaviour was observed most explicitly in the elaborative group, but there is no reason to suppose that it was not occurring in the other two groups. Even in the sequential group, where modules were viewed in a very linear-type manner, each new module would have been interpreted through the material contained in the past modules (and the subjects' previous experience). The sequential subjects did engage in a limited review of some modules in what could be considered a series of situated actions. These observations would seem to support the general notion of situated actions occurring within a framework of plans. Therefore, it could be inferred that CBT needs to support situated actions by allowing the trainees to adapt and change their learning strategy throughout the training as required.

5.3.2.2. Hypermedia

A recent revival of self-directed environments has been heralded by the advent of hypermedia. The hypermedia environment is much freer than the non-linear condition reported in this investigation. It has the potential to allow linkages and access between all parts of the knowledge domain. In this investigation, however, the choice between training modules was taken at the point of the overview screen, to which subjects were required to return (see section 3.2.2.1.). Despite the relatively simple network in this investigation, the two environments did have similarities. The use of hypermedia for education and training has been advocated because it gives control to the learner by encouraging exploration (as opposed to the AI approach, which seeks to intelligently make many of the decisions for the learner). However, there are a number of potential drawbacks intrinsic to such systems that also apply to the non-linear condition.

The most often cited disadvantage is disorientation or 'getting lost' (Conklin, 1987; Hammond & Allinson, 1989; Edwards & Hardman, 1989). The network in the non-linear condition was quite simple, and yet six subjects did report becoming lost at some point in the training session, (possible reasons for this are also discussed in section 5.2.3.3.). Therefore disorientation is a problem even in relatively simple networks. The sheer size of a network may cause users greater navigational problems. Some research has proposed the use of navigational tools using the travel metaphor to assist learner around the knowledge domain (Hammond & Allinson, 1989). Mayes, Kibby & Anderson (1989) suggest that this may be inadequate for large networks as they do not help the learner navigate in conceptual space. They propose conceptual orientation of the material rather than spatial orientation of the nodes and links in the network, as the learner's goal is to become orientated conceptually rather than spatially. Mayes et al suggest that this will facilitate learning; learners are forced to concentrate on shared attributes between frames rather than the structure of the network. The relatively shallow nature of the non-linear condition should have helped subjects concentrate on the task, rather than the network, but problems associated with cognitive overhead, motivation, knowing content and learning to use the interface cannot be ruled out.

Cognitive overhead (Conklin, 1987; Doland, 1989) is the term given to describe degree of complexity in a non-linear environment such as; number of choices, task scheduling, tracking and navigating. This is related to the management function the subject was required to perform in the non-linear condition, including the decisions related to which modules to select and in which order to select them. As has already been suggested in section 5.3.2.1. the further through the training session, the better the decision probably is. This is undoubtedly linked to the subjects becoming aware of content of the modules from implications of what has already been covered (Hammond, 1989; Doland, 1989). It is also a function of reduced number of choices making the decision easier.

Motivation of learners may be impaired if they become overwhelmed by the freedom allowed in the learning environment. Subjects who behaved in a sequential manner were able to get around the problem of freedom and ambiguity by using the overview screen to structure the task. However in more complex networks where the structure is not so visible it might be necessary to provide some initial constraints, such as in the training wheels philosophy (Carroll, 1984) or guided exploration (Robertson, Koizumi & Marsella, 1988), to prevent the trainee becoming unmotivated and just rambling aimlessly through the network. Such interaction may lead to a situation of 'taught helplessness' (Norman, 1988).

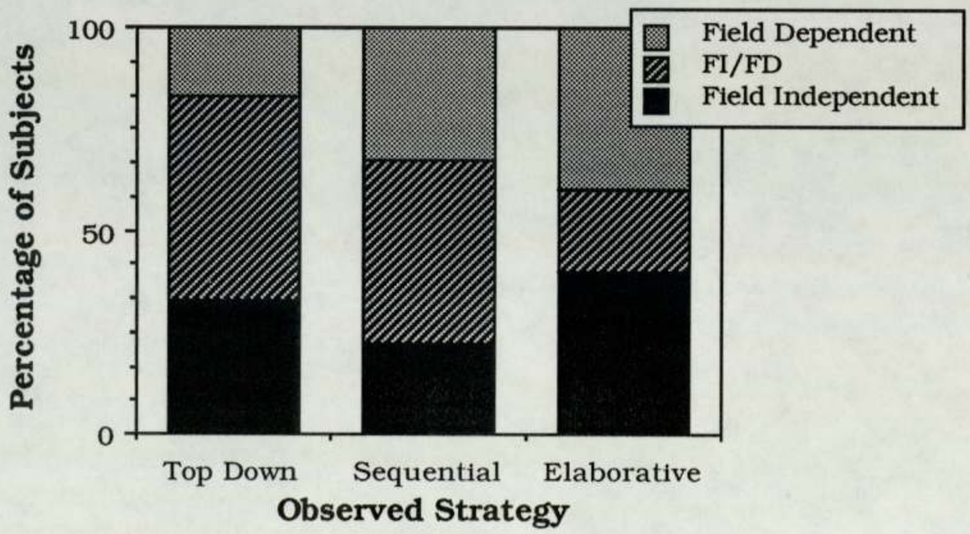
The non-linear interface (like the hypermedia interface) is relatively new, none of the subjects in the experimental condition had ever encountered such an environment before. Therefore it had to be learnt. Subjects in this condition were required to learn this task on top of learning to use the interface and become self directed. These additional tasks must have put extra load onto the subjects. Mayes et al (1989) reported that with their system subjects either learn to navigate in the system or learn the instructional material, but they cannot do the two together, at least in the initial stages. The non-linear environment was relatively simple, and it is proposed that this initial problem was relatively short-lived as is shown by the change over time in performance differences.

5.3.2.3. Cognitive Maps

Related to the notion of mental models is the idea of cognitive maps; the internal representation of external spatial information. Billingsley (1982) found that a pictorial representation of a menu structure assisted subjects develop a mental model of the interrelationships of data. This proved to be significantly more effective than providing an index or no assistance at all. Subjects reported in this thesis were provided with a pictorial representation of the first level in the non-linear hierarchy (see figure 34), but not the second level as shown in figure 33. In addition the interrelationships were only visible at the point of the overview screen, and as soon as the subject moved to another point in the system they were required to navigate via dialogue boxes (as shown in figure 35). From Billingsley's work, it seems clear that users of non-linear environments need pictorial representations of their environment in order to alleviate navigational problems. Further evidence from research reported on the acquisition and use of spatial knowledge in the physical world (Smyth, Morris, Levy & Ellis, 1987) may also be applicable to navigation in an electronic medium. Application of cognitive mapping to hypertext environments has suggested that readers form a spatial cognitive map (Edwards & Hardman, 1989). It appears that individuals attempt to create representations in the form of survey-type maps for orienting and navigating around hypertext. It is therefore suggested that the electronic environment support the analogy of navigation based on the physical environment. Edwards & Hardman demonstrated that under certain conditions it was possible to disrupt the development (and therefore successful navigation) of cognitive maps, by not fully supporting the physical analogy.

5.3.2.4. Cognitive Style
Cognitive style was examined along the dimension of field dependence/ field independence. This particular dimension was chosen for investigation because it has been postulated that it can be related to learning behaviour. It was considered to be particularly applicable for investigating differences in behaviour in the non-linear environment because of the claim that it differentiates between the extent to which an individual structures and analyses incoming information (Robertson, 1982). Field independent individuals are characterised by structuring information, whereas field dependent individuals tend to be less analytical. The non-linear environment was essentially unstructured, and allowed subjects to assert their own structure on it through sequencing the training modules.

The attempt to identify cognitive styles through the EFT was not conclusive as shown in graph 20.



Graph 20. Percentage of field dependent/independent subjects in the observed groups.

Although not statistically significant, the top down group a smaller percentage of field dependent subjects than the other two groups.

Fowler and Murray (1987) noted that FD subjects tend to 'build up' a mental model through 'hands on' experience, whereas FI subjects tend to 'fill in' a mental model with experience, the structure of which is developed prior to interaction. This may explain why top down subjects were able to place structure on the non-linear environment. This finding is further supported by Fowler, Macaulay & Siripoksup (1987) who reported that FD individuals do not readily structure information presented to them whereas FI individuals impose structure where it is lacking.

Fowler et al. (1987) reported that field independent individuals adopt more complex learning strategies which are likely to produce slower performances initially. The TD group also viewed significantly less modules as they were able to make greater inferences about the content of 'lower-order' modules when approaching the training top down. However, as mentioned previously there is more to learning strategy than cognitive style. For example, environmental factors (such as; task material, surroundings, familiarity, time pressures and anxiety) may mediate or interact with an individual's strategy (Fowler & Murray, 1987).

Although transfer performance in the process control task is initially significantly better in the non-linear condition, there is no significant difference in the task performance between the groups within the non-linear condition. This indicates that subjects were more able to process the information in a sequence that was congruent to their own cognitive style (e.g. Brooks et al, 1985).

The findings presented show that there may be some basis for examining cognitive style, but caution should be taken when using this to interpret learning strategy. Previous knowledge can be used as a base from which the learners can develop their own cognitive structures (Hartley, 1985). Non linear training environments support the development of such structures which in turn will influence the learners' choice of subsequent modules. Therefore the tools provided for guidance should reflect this eventuality, allowing learners to maintain control and responsibility for their learning and structuring of information and to sequence it in a manner that is meaningful to them. Caution should be used in approaching the issue of categorisation of cognitive style. We should not be too rigid in our thinking about styles, and use the available media to allow for the widest individual variations, rather than prematurely and permanently classifying learners.

5.3.2.5. Learning Strategy

As Messick (1976) noted, cognitive styles are different to cognitive strategies. Styles are related to a predisposition of behaviour whereas strategies are the translation of the predisposition in combination with the multi-factorial environmental, situational, and social variables. This may help explain why the results from the EFT were so inconclusive, and perhaps effort would be better expended on examining learning strategies. There does not appear to be one overriding strategy that can be used to provide guidelines for structuring training modules in one particular sequence. As Allinson & Hammond (1989) warn, the dangers of presenting material in a manner that suits one particular style, is such that individuals that approach the material from another perspective may well be frustrated in their goal of assimilating the material into their own cognitive structures. Furthermore, it is just as likely that individuals do not operate solely from one particular style or strategy, but that they are capable of switching as factors change such as material familiarity, structure of material, motivation to learn, etc. Given this, it seems clear that any training environment must be designed to allow for different learning strategies. Unlike previous studies, this investigation directly compared linear and non-linear training environments. From the findings it is clear that a non-linear environment is superior. The advantages postulated being that it:

- allows for different levels of prior knowledge
- encourages exploration
- enables subjects to see a sub-task as part of the whole task
- allows subjects to adapt material to their own learning strategy.

This suggest that the non-linear environment is supportive of a wide range of strategies, whilst not actually biased towards one. The instructional material is passive, requiring the subject to be active in response to their changing knowledge base (see figure 42). Brooks et al (1985) agree that the effort of researchers would be better directed at the relationship between individual differences and learning strategies. They suggest that the four general categories of individual differences that relate to learning strategies are; abilities, cognitive style, prior knowledge and affect/motivation. These however cannot be considered in isolation, and research has to take in the whole learning strategies framework for reliable advances to be made. A possible criticism of this investigation is its failure to account for the variables relating to abilities and prior knowledge. However all subjects were of undergraduate educational level, but some may have been more familiar with computing technology than others. These are rather minor criticisms given the size of the study, and the tentative nature of the findings.

5.3.3. Summary

The non-linear, learner centred, methodology does appear to have given some insight into the individual differences in learner behaviour. Learners do behave differently, and some seem to prefer autonomy, whilst others may have preferred to have been led through the training. Three ways of analysing the results were presented. The most reliable appears to have been an analysis based upon the experimenter's observations of the subjects' behaviour. Under this analysis three major classifications of behaviour emerged: top down, sequential and elaborative. The top down group were characterised by choosing the more complex modules first and typically viewed significantly less than the other groups. The sequential group relied on the overview screen as a visual prompt for choosing the order of the modules, but may have reviewed some modules at the end of the sequence. Finally the elaborative group were characterised by moving between simple and complex modules and typically viewed more modules than the other groups, but spent less time in each module. Perhaps the most interesting finding is that although the non-linear environment enabled these different strategies to occur, there was no significance difference in the transfer task performance between the three groups. This suggests that each individual had been able to assimilate the material in an appropriate manner that supported their own internal cognitive structures. In short, the non-linear environment supported situated actions and allowed subjects to manipulate the learning to suit their own requirements. These may have been changing throughout the learning task, and therefore it may have been inappropriate to pre-structure them.

There were some lessons to be learnt, however. Some subjects did report becoming disorientated in the non-linear environment. This suggests that there is a need for spatial cues to be provided in order that learners are able to better navigate in this type of environment. Subjects were required to carry out three tasks, one was to learn the material, the second was to learn to interface, and the third was to manage their learning. The second of these should have been transparent and may not put additional load on the subjects. Whilst it is recognised that the third seems to have helped the subjects perform the first to greater effect.

In summary, it appears that learners were able to sequence the training modules in an individual manner, however this was not statistically linked to the measure of cognitive style provided by the dimensions of field dependence. It is most likely that the form of measuring cognitive style was inappropriate. In addition, the subjects' observed behaviour needs to be considered within the context of the changing nature of their own cognitive structures. Therefore their behaviour was more likely to be adaptive, rather than predetermined.

5.4. SELF ASSESSMENT

The last main section of the results analysed the data of subjects who made explicit judgments about their confidence in specific responses in the practice modules (called the self assessment condition). This judgment was made in response to a self assessment question asking subjects to rate their confidence with the action (or sequence of actions) prior to feedback. This condition was compared to the condition without self assessment (the control condition). Both conditions were identical in all other respects. The results are considered further in section 5.4.1., their implications in section 5.4.2. and they are summarised in section 5.4.3.

5.4.1. Training Session and Transfer Task

Comparisons can be made of the differences between training and transfer behaviour and performance. These are dealt with separately in the following two sections.

5.4.1.1. Training Session

As graph 14 shows there was a significant variation in the amount of time spent by subjects between the two conditions. Further analysis showed that this effect was mainly due to three of the practice conditions, namely; Principles Practice, Keyboard Practice and Delete Practice (content of these modules is outlined in section 2.2.). Closer examination showed that for two of the modules subjects in the self assessment condition spent significantly longer in the modules (Principles and Keyboard) whilst for the Delete module they spent significantly less time than subjects in the control condition. The reason for this effect may be related to the introspective nature of self assessment. The Principles module was the first training module to be encountered, and therefore the extra time taken by the self assessment subjects could be attributed to the subjects orientating themselves to the task of self assessment. Similarly the Keyboard module was the third module to be encountered and had five separate questions, each with its own self assessment, increasing the degree of difference between the two conditions, and the extra task that was required to be undertaken by the self assessment subjects. What is puzzling is that subjects in the control condition should take longer in the Delete module. Visual examination of graph 14 may give a clue to this effect. The general trend seems to be for the self assessment subjects to spend longer than the control condition in the first two thirds of the training modules. In the last third of the modules the self assessment subjects appear to be quicker than subjects in the control condition, although this is only significant in the Delete Practice (called D.Test in graph 14) module. This trend may be due to the self assessment subjects becoming more efficient learners, maybe through increased self direction (see figure 40).

There were no other behavioural differences between the two conditions to report in the training session. No significant difference was found between the number of modules that were completed or repeated. This shows that extra time spent in the modules was not simply a function of more modules being repeated in one of the conditions. There was also no significant difference in the performance in the training modules (i.e. the number correct) between the two conditions.

Closer analysis of the self assessment condition with respect to the self assessment question (see graph 16) shows that the confidence ranking is initially low (where P1 is the first confidence question in Principle Practice). The second question achieves a much higher confidence ranking (P2 the second confidence question in Principles Practice) presumably due to the feedback (or positive reinforcement) that the first question was correct. This ranking remains stable until K4 and K5 (the last two Keyboard Practice confidence questions) where the ranking dips down. This reduction in confidence can be correlated with the increased time spent by self assessment subjects in the module (discussed earlier in this section) and the performance of subjects in this module (shown in appendix 9) where eight of the twenty subjects made at least one error in responding to the task set. The confidence ranking then improves in subsequent modules. The trend seems to suggest that if subjects initially rank their confidence low, if they are proved to be correct in their assumptions then the confidence ranking increases, but if they are proved wrong then the ranking decreases. This is probably also mediated by the complexity of the task, and the degree of ambiguity the subjects feel. The Output Practice (O1 on graph 16) and Delete Practice (D1) on graph 16) are both ranked fairly highly, but should also be relatively straightforward by this time in the training session. However a dip in the confidence rating is observed in the last module Fault Finding Practice (F1 on graph 16) which is the most complex of all the practice modules and requires subjects to use all previously learnt skills together with some new ones. The reduction in the rating (compared with O1 and D1) could be due to the mediating effects of bringing all these skills to bear on a new task, despite the recent success in the last two modules. Overall however none of these differences were significant, and therefore the observations are speculative.

The self confidence questionnaire analysis (section 4.4.7.) showed that there was no significant differences for any of the scales between the two conditions. Therefore none of the reported differences between the conditions could be related to greater confidence. This is also true for the findings within the self assessment condition.

5.4.1.2. Transfer Task

The results from the transfer task showed a marginal difference approaching significance between the two conditions (as shown in graph 17) where the self assessment subjects performed better than the control subjects. This margin is removed through the transfer session when interaction with the task seems to aid learners in achieving optimum performance (i.e. subjects were still learning in both conditions through hands-on experience). This was a process akin to polishing up performance, the basic principles of operation already having been learnt in the training session.

Both condition improved significantly from the transfer session to the retention session one week later. Graph 18 shows that the improvement was greater for subjects in the control condition (or non-SA condition on graph 18) because their performance was not as good as self assessment subjects in the transfer session. There was no statistical difference between the conditions on the retention task, as subjects appear to have reached optimum performance.

5.4.1.3. Summary

The addition of self assessment to the practice modules appears to have had some effect on the training behaviour and the transfer performance. Orientation to self assessment seems to have led to a more effective and possibly self directed training behaviour. The transfer effect of this seems to have improved task performance marginally at least, although the difference disappeared with extended interaction with the task.

5.4.2. Related Issues

From the interpretation of the results it became apparent that there are many factors that need to be considered. Despite the self assessment condition only fulfilling the second half the criteria set by Boud (1986), i.e. that subjects should identify the standards or criteria and make judgments about their work along these, there were some interesting differences between the conditions. There were, however, a number of reasons why it was not possible for subjects to identify their criteria. Firstly, to enable subjects to identify what criteria they should be assessed against would presuppose that they already have some knowledge of what it is they were to do. This is quite possible in education, where most of the research into self assessment is directed, but not always as easy in training where the material to be learnt may not have been encountered before. Secondly, the task is made even more difficult in computer based training, which requires some intelligence on behalf of the program to allow subjects to select their criteria, and then judge themselves against them. Thirdly, it is not really what the study was about. The aims of the investigation were to explore the situation where the subjects assessed their level of confidence with an action (or series of actions) in response to a request. This was seen as a means of highlighting the state of their own level of knowledge, rather than assessing their performance for a grade.

5.4.2.1. Learning to Self Assess

Accurate self assessment is not an innate skill, indeed there is a tendency for people to view themselves as responsible for positive outcomes and others (or machines) as responsible for negative outcomes. This bias can cloud the objectivity required in self assessment. Falchikov & Boud (1989) submit that the self assessment skill requires training and development. They further suggest that the self assessment itself can be a valuable learning activity, particularly the loop between the self assessment and the feedback to the student, even if there is no agreement. The gap in agreement is usually greatest for inexperienced self assessors. In one study it was demonstrated that training in self assessment showed greatest effect for low, rather than high (as derived from an introductory psychology test), achievers in confidence judgments relating to the correctness of an answer

(Zechmeister, Rush & Markell, 1986). This points to the assertion that the ability to self assess is related to individual factors, but that it can be trained. As Boud & Falchikov (1988) assert 'good' students have always been effective self assessors, but this skill needs to be more widely developed and practised to help all learners become more effective through realising their own strengths and weaknesses. This knowledge may help them direct their efforts to the most productive areas. This may explain why subjects in the self assessment condition took longer in the training modules initially, they were learning to self assess even though they did not 'own' the criteria, which helped them become more effective learners towards the end of the training (as time in the modules decreased for this condition) and led to 'improved' transfer. On an optimistic note, Richardson (1978) observed:

> "There is reason to believe that self assessment and self monitoring activities including training students in basic and generalizable skills of self observation and self assessment of progress or change, hold considerable promise for enhancing the quality and generalizability of learning in a wide variety of academic and skill training programmes."

5.4.2.2. Individual Factors

As figure 40 shows self assessment is one dimension which can increase autonomy in learning. It enables students to take greater responsibility for their own learning. This opens up the possibility for influence by individual factors that are now under consideration. The ability of the self assessor is the most frequently cited variable, as Falchikov & Boud (1989) summarise "more able students make more accurate assessments than their less able peers". In a review of the literature of self assessment in education Boud & Falchikov (1988) conclude that:

- there was no clear tendency for self assessors to over/under rate themselves, under different circumstances, different results were observed.

- high achieving students tend to be more realistic and maybe underrate their performance whilst low achieving students tend to over-estimate their achievements to a greater extent than under-estimate them

- more experienced students either become more accurate, or tend towards increasing underestimation of their performance

- there is a lack of studies to draw any firm conclusions regarding the influence of practice on self assessment

- research suggests that students tend to overrate themselves when the self assessment is used for grade purposes

- there is no conclusive evidence for gender differences in self assessment, the results go both ways.

Boud & Falchikov are critical of the inadequacies of many of the studies but are able to conclude with the common sense predictions that more experienced and more able students are better self assessors than their less experienced and less able peers. This investigation could be similarly criticised in the respect that no measure of ability was taken (although all subjects were of an undergraduate educational level). The results indicate that subjects were mainly influenced by; the novelty (subject ratings in the first module were low, and they had probably never encountered CBT, self assessment, or the material before) and experience (subject ratings in the second module was improved, probably due to increased confidence with initial success) of the situation, errors (where errors occurred confidence was generally low), ease (confidence was higher for less complex material) and difficulty (more complex material reduced confidence rankings) of the material. These findings relate to the general trend of a cumulative summary of the results. Visual examination of the raw data (appendix 14) shows that some individuals were more confident with their actions than others, which suggests that individual factors come into play. There does not appear to be a direct mapping between performance and rated confidence either. This could be due to one of two reasons. Either the subjects simply entered the wrong confidence rating, or the rating had rather more subtle influences. The entered rating is likely to be result from the subjects' perception of their performance in the training situation. They may genuinely not feel absolutely confident with an action, but it could still be correct. Likewise, a confident response may not necessarily be a correct one, and the compensation of over-confidence may be a means of covering this up. It could reasonably be argued that the training period was not really long enough for subjects to get used to the self assessment technique. However it still seems to have had some benefit, as Falchikov & Boud (1989) point out, self assessment can still be an important learning activity even if there is no agreement between the confidence rating and observed outcome.

5.4.2.3. Confidence and Motivation

Some parallels could be drawn between the self assessment component of the training and the work carried out by Anderson (1982) who cites Echternacht (1972) defining confidence testing in multiple choice as:

> "a method of testing where weights are assigned directly or indirectly to item responses in such a way as to reflect the examinee's belief in the correctness of the alternative or alternatives so marked".

Anderson suggests that the potential benefits of such procedures are; increased reliability of scores, improved evaluation of the alternatives, availability of further diagnostic information and greater examinee satisfaction.

All of these factors could potentially be applicable to this investigation also, despite some marked differences in the implementation of the two studies. Anderson's example involved probabilistic confidence testing, whereas this investigation encouraged subjects to engage in an activity (ranging from one to a series of actions) before rating their confidence on a five point likert-type scale. However, the assigning of confidence ratings (be they probabilistic or scales) to responses as a means of getting a clearer picture of the actual state of the subjects knowledge seems reasonable. The problem is that the level of perceived confidence may be influenced by a variety of factors (as discussed in section 5.4.2.2.), and therefore may not be as reliable as Anderson claims. The second point that is made examines the improvement in the subjects' behaviour. The suggestion is that accuracy increases with continual feedback, and that requiring students to make ratings of their confidence makes them more critical and stimulates relevant information seeking. Hunt (1982) noticed this effect, reporting that self assessment increased the attention paid by learners to the learning task. Further, Stammers (1985, b) surmises that this effect could be explained by the self assessment procedure encouraging the learner to focus on their current state of knowledge against the desired outcome. Anderson reports that previous studies demonstrated that a measure of confidence with response did result in better learning performance, but admits that the self assessment process itself benefited from training and experience.

The third potential benefit that was put forward was the use of self assessment information for diagnostic purposes of learners' behaviour. It may give some insight into problems the learner is encountering in the learning process. For example, if a wrong response is continually accompanied by a very confident rating, or a right response is consistently accompanied by a non-confident rating, the learner may be experiencing difficulties with the training material, the approach, the self assessment or the medium. The learner will also be aware of this information through feedback, which may be resolved without intervention. However, whatever the solution, the procedure does make the provision for extra information to be made available.

Anderson's last proposal was that the self assessment process generally increases satisfaction and reduces anxiety in examinees. He claims that this results from the increased scope to establish position more clearly on each response. Wade (1974) found that self monitoring led to higher motivational ratings amongst learners compared to those who did not monitor themselves.

The cumulative effect of all of these propositions is that subjects involved in the assessment process become more aware of the learning they are undertaking. They examine the state of their own knowledge more carefully and thus attend to the relevant areas of the task. They feel that they can express their understanding more clearly and therefore perceive greater motivation and satisfaction with the learning experience.

5.4.2.4. Metaknowledge, Metacogntion & Metamemory

The study of self assessment assumes that the individual is able to have some knowledge of their own knowledge (metaknowledge). This is at odds with the current understanding of the cognitive process (Norman, 1988), which it is suggested that a large part of our mind is directly inaccessible (the subconscious) and a good deal of what we remember is unreliable. In addition, the process of attempting to form some opinion on the state of a particular aspect of our knowledge, which is newly acquired, may alter the very state of this knowledge. This itself may give an insight into the processes that led to the limited reported success of self assessment in the laboratory. Take for instance the following scenario; the newly acquired information is still in working memory when the subject is required to make some assessment about it, having first used it to perform some function. This could be seen as an extended form of rehearsal, with the subject reprocessing the material (probably in their own terms as this is the third time around; the first was learnt, the second was practice, the third was assessed) before a final processing when the outcome is known. Given the extra attention paid to the task and increased motivation, it is perhaps not too surprising that there is some increased learning and performance payoff. Another consideration is that metaknowledge may be like a plan; people are very capable of offering post hoc justifications or explanations for behaviour that they may not necessarily been aware of at the time of carrying out the actions. Metaknowledge may be considered to be like a plan: people are very capable of offering post hoc justification or explanation for behaviour.

The basis of making decisions on what is known and not known is a metacognitive skill and evidence suggests that this information is far from perfect in many individuals (Zechmeister et al, 1986). There may be a metamemorial bias (as there is bias for all contents of memory) that leads to over/under confidence with subjects actions. A 'visual' comparison of the training performance and the self assessment question data in this investigation confirm this observation (as discussed in section 5.4.2.2.). However as mentioned in section 5.4.2.1. this skill can be improved with training.

The metamemorial bias may also hinder the learning of new information, as Zechmeister et al (1986) point out, the effort expended in acquisition will, to some extent at least, depend upon the assessment of the current state of knowledge. For instance, an individual who is overconfident of their state of knowledge on a particular topic may not be as efficient in their use of learning strategies, as a more realistic assessment would cause them to be. This in turn may lead to a shortfall in expected performance level on the basis of the confidence predicted.

As Shaughnessy (1979) surmised, the truly independent learner is required to not only be able to acquire new information, but must also assess the quality of encoding activities accurately. This places emphasis on the learners' internal feedback regarding the ongoing cognitive activities. Shaughnessy's study examined memory monitoring ability and the effects on leaning performance, a four point scale was used. (definitely incorrect, probably incorrect, probably correct, definitely correct). The results suggested that even the poorest students had some degree of memory monitoring ability, and that this can be improved by the training of more effective ways of evaluating learning.

Clearly there is not enough known about the cognitive functioning of individuals (Norman, 1980) to speculate much further, and this remains an open area for further research.

5.4.2.5. Other Factors

As mentioned previously, the self assessment process adds another dimension to the learning environment. It gives subjects some level of autonomy and responsibility for their own learning. It provides another means of expression, and is opinion, rather then factually, based and involves the learner in another activity alongside the main task of learning. Stammers (1985) in a review paper suggested three main ways that self assessment adds to the training process. Firstly, it increases the role of the trainee and makes the role less passive. Secondly, it increases the trainees' awareness of their current level of knowledge and competence with the task (as discussed in section 5.4.2.4.). Thirdly, it raises their attention towards the outcome of their response related to the correct response (as discussed in section 5.4.2.3.). The increased activity had been considered by Hunt (1982) who attempted to determine if this was entirely due to the motor component of the assessment. The results did suggest that the motor activity was responsible for the findings. However, his study was flawed. The paired associate task had a button labelled record (which in fact did nothing). Hunt pointed out that the label 'Record' may have been enough to initiate the extra cognitive activity. Therefore one should not attach too much credence to his findings.

Different researchers have used different confidence scales. Hunt (1982) claims that an 8-point scale is most effective. Shaughnessy (1979) used a 4-point scale. Wen's (1975) 3-point scale is reported to have been used in most implementations of confidence weightings (Anderson, 1982). This investigation however used the Likert-type 5-point scale as a compromise on offering too much choice that it becomes unreliable, and too little choice that it is inflexible. This idea comes more from the expertise in questionnaire design (Readyguide, 1982) rather than confidence testing.

Another pitfall that concerns research on confidence judgments is the question of the individuals' own 'schema' of what they regard as 'very confident' or 'very unconfident'. This may vary between individuals, as may their own level of self confidence. One suggested way around this problem is to calibrate subjects before the experiment starts. This however can cause its own problems as introducing individuals to the notion of assessing themselves can change their behaviour, as discussed in 5.4.2.4. This effect is well known in the use of verbal protocol for knowledge elicitation. Diaper (1989) cites examples that show people changing their behaviour so that it may be reported more easily. Clearly, the elicitation process may interfere with the information that it requires.

5.4.3. Summary

It is seems clear that SA did enhance learning and transfer, and the cost of this enhancement was minimal. Development of the CBT package took in the region of 300 hours, the extra time taken to create and insert the SA questionnaire was is estimated at one hour. In terms of training time, all subjects took between 1/2 to 3/4 of an hour. This is balanced by the total time spent in SA of 1.5-2 minutes.

SA can certainly be usefully added to existing training packages, and does not take up much administration time. The cost-benefit relationship seems to very much in its favour. This study therefore supports Hunt's original findings. By using a training task of an industrial nature, rather than paired associate learning, it has been demonstrated that Hunt's findings can be generalised.

The implication of the finding of this study is that introducing SA into CBT serves to increase the attention paid by the trainee to the learning task. This will result in better 'first shot' performance. Stammers (1985) further suggested that SA may provide richer information about the learner's state of knowledge, e.g. an answer could be correct but may be a guess, and the trainee can indicate low confidence in its accuracy. This information could be used for the decision to present differing levels of remedial information based upon the outcome of the response.

In summary, the results of this investigation show that the use of SA in training may change learning behaviour and improve transfer task performance. This is probably achieved through, increased interaction between learner and computer, introspection of knowledge state and a comparison of this against the results by the trainees. Whilst it may be argued that ownership of criteria (Boud, 1986) would have shown even more dramatic effects, some improvements were apparent even without it. The notion of ownership of criteria, refers to the learners eliciting the criteria which they then rate themselves against. These criteria are then owned by the learner. It has been suggested that the commitment of the learner to the criteria is greater if they are personal, rather than generated by the assessor. However, it is quite difficult to elicit criteria when the subject matter is unknown to the learner.

6. CONCLUSIONS & RECOMMENDATIONS

Whilst the introduction highlighted that little is known about the learning process, this research has shown that progress can be made by providing an optimum environment within which learning can occur. This environment may be manipulated to improve the learning process. A 'goodness of fit' is required between the learner and the learning environment in order to maximise the uptake of the material to be learnt. In general, the hypotheses do appear to have been supported by this empirical study:

a) Providing learners with control over the sequencing of training modules led to better transfer performance.

b) Learners in the non-linear environment appear to have sequenced the training modules in a manner that was congruent with their preferred learning strategy.

c) Self assessment lead to a marginal improvement in initial transfer performance.

These findings are presented cautiously, and are qualified in greater detail in sections 5.2., 5.3. and 5.4 respectively. The findings underline the notion of learning as an active process. Therefore the more pro-active the learner is, the more effective the learning process will be. Conversely, the more passive the learner is, the less effective the learning process will be. This is a rather gross overgeneralisation. However, it indicates that the greater involvement learners have in their own learning, the better the subsequent transfer performance will be. This postulation is supported by the data, showing that: a non-linear environment and a self assessment procedure was more effective that a linear training condition. The principle to emerge from this study is that the learning environment needs to be flexible enough to support the learner.

Throughout this study lessons were learnt regarding the design of CBT. Some of these may be useful for future research projects to enhance

CBT design. The first of the pitfalls was the provision of a short time delay (no more than 5 seconds) to force the subject to read the text and examine the graphics within the training modules. This measure proved to be unpopular as reported by the subject opinion questionnaire. Many enhancements could be implemented within the non-linear training environment. Subjects reported very little use of the index facility that was intended to provide a brief summary of the content of each module. This could be improved by making the summary available more directly from the overview screen. The training modules could be broken down even further into chunks of information, so that the learner does not have to plough through the whole module if they are satisfied that they understand a higher level introduction. The navigational aspects of the network could be made more flexible by providing greater links. However this would need to be accompanied by the implementation of spatial maps, so that users could navigate around the network without becoming disorientated. Meaningful links could be used to join any part of the course with any other. The physical representation of the course would represent a three dimensional nodal network.

This thesis proposes a few questions of its own. Self directed learning needs further exploration in the area of computer based training. The potential benefits promised it terms of learners' performance both in the learning task and subsequently on the task make the issue an important one. This research covered the dimensions: method, pace, monitoring and assessment. That still leaves other dimensions such as: aims, place and materials unexplored. Further still, the combination of non-linear and self assessment within the same training programme is worthy of further research. Both the non-linear and self assessment dimensions of the study need to be separately explored further. Hypermedia provides new possibilities for training. This follows from the idea that text and graphics can be linked in a knowledge network, allowing the learner to approach the material in a non-linear manner. Therefore the learner has the freedom to adapt the material to their own preferred learning strategy, and go into the level of detail required for their purpose. There is a variety of software such as Guide™, HyperCard™ and CourseBuilder™ that enable the relatively computer naive individual to produce working software within a matter of hours. This is not to say that the task is an easy one. Poor links may be worse than none, giving the learner an incorrect model of the task. The interface may also lead the learner to suffer problems related to cognitive overhead. Principles of cognitive mapping from three dimensional spatial environments need to be derived to investigate the navigational aspects of hypermedia. The learner should not be so distracted by the medium that they are unable to concentrate on the material to be learnt. Finally, CBT studies need to investigate the proposal that self assessment is most effective when the criteria for assessment are personal to, and have been chosen by, the learner. This can be classified as the contrast between self assessment and self ranking. The research question is: does the elicitation of the criteria (and therefore the personal ownership of the criteria) really make any difference? These points are in summary:

- Further exploration of all the SDL dimensions.
- Combination of NL and SA.
- Investigation of Hypermedia for training.
- Derivation of cognitive mapping principles.
- Fuller implementation of SA in CBT.

Each of these topics will in turn raise their own questions, and like this study, provide the ground work for further exploration.

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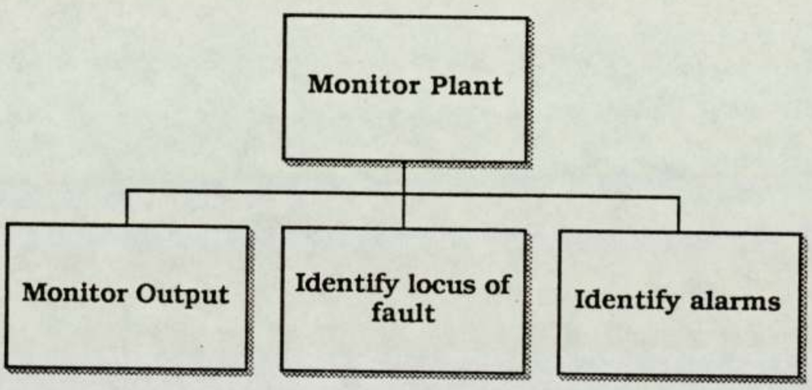
8. APPENDICES

Script for Process Control Simulator.

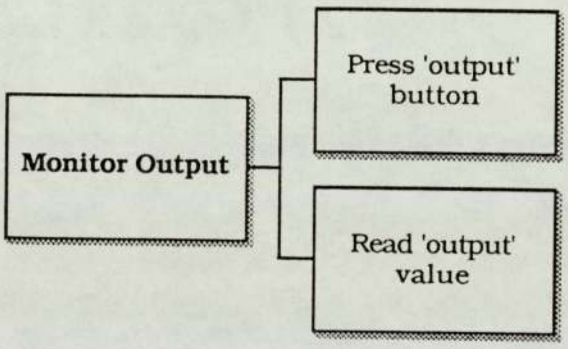
Event No.	Time Started	Colour	Number	Type
1	0080	Blue	6	Long
2	0128	Green	6	Long
3	0136	Blue	3	Short
4	0232	Red	3	Short
5	0332	Blue	1	Short
6	0336	Blue	2	Short
7	0334	Green	4	Long
8	0348	Red	0	Long
9	0384	Blue	2	Long
10	0420	Green	7	Long
11	0508	Blue	5	Long
12	0528	Red	0	Short
13	0548	Red	4	Short
14	0656	Red	1	Short
15	0680	Red	7	Long
16	0712	Blue	7	Long
17	0768	Red	2	Long
18	0828	Red	6	Long
19	0836	Blue	8	Short
20	0876	Blue	8	Long
21	0940	Green	1	Long
22	1080	Green	6	Short
23	1192	Blue	8	Long
24	1196	Red	6	Short
25	1344	Red	8	Long
26	1400	Green	0	Short
27	1564	Green	5	Long
28	1572	Red	6	Long
29	1588	Red	4	Short
30	1664	Green	0	Long
31	1800	End		

Appendix 1. Script

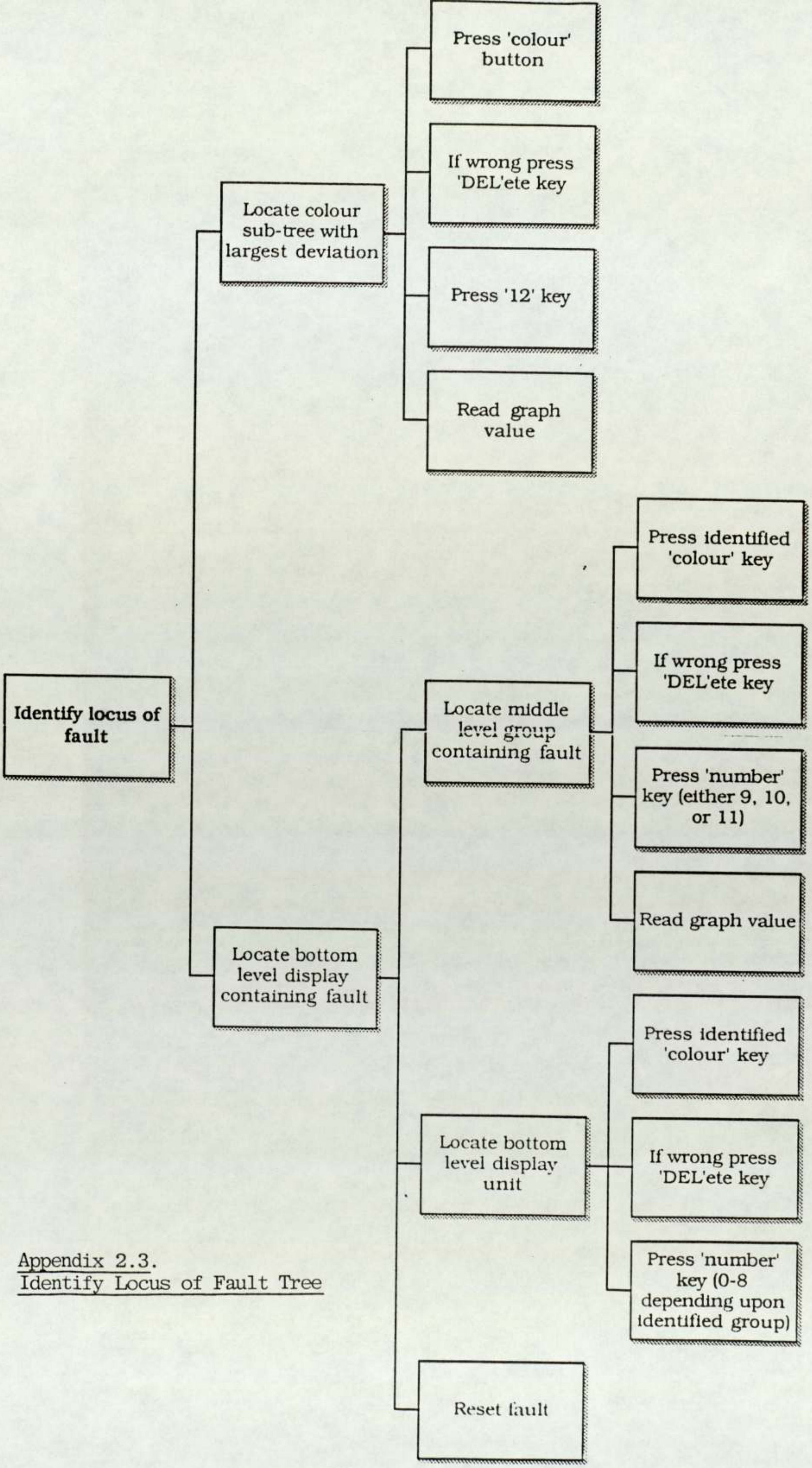
Appendix 2. Hierarchical Task Analysis



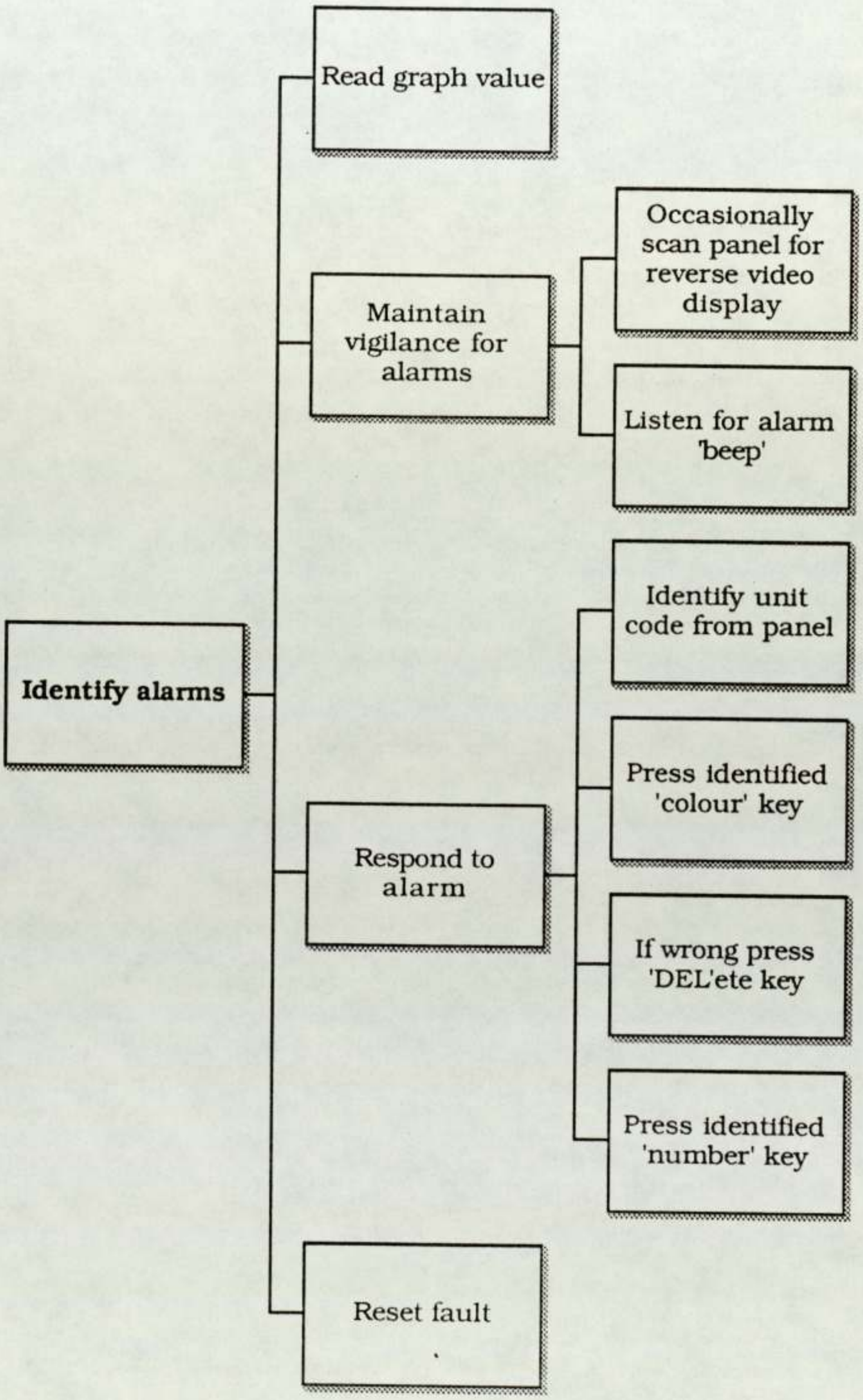
Appendix 2.1. Monitor Plant Tree



Appendix 2.2. Monitor Output Tree



Appendix 2.3.
Identify Locus of Fault Tree



Appendix 2.4. Identify Alarms Tree

Appendix 2.5. HTA Descriptions

Monitor Plant

The goal of this task is to keep the 'output' level as low as possible whilst running the plant. This includes the task of avoiding alarm states by interrogating the plant to find and reset deviations before they reach the alarm limit. If the alarm panel is activated then the operator must respond immediately.

1. Monitor Output

The operator continues to monitor the 'output' graph (only selecting the 'output' key once), which updates continuously, until the arrowhead rises from zero, indicating that there is a deviation in one of the bottom level units. The the operators starts to search for the fault.

1.1. Press 'output' button

This only needs to be selected once and the graph will be displayed, continuousy updating itself every few seconds. The output key is located on the left hand side of the keyboard under the 'RESET' button. Feedback to the input is given in the 'operation log'.

1.2. Read 'output' value

The operator reads the 'output' value continuously until a deviation appears, and then starts to trace the fault. The value appears as a point (denoted by an arrowhead) on a historical graph. All graphs appear in the bottom left hand corner of the screen.

2. Identify locus of fault

The operator searches through the monitor heirarchy to identify the faulty unit. This is started by first locating the colour sub-tree.

2.1. Locate colour sub-tree with largest deviation

The operator should read all of the graphs at the top level (R12, B12, G12) and decide which contains the largest deviation. This is followed first, and the operator returns to deal with the smaller deviations later.

2.1.1. Press 'colour' button

The colour keys are laid out in the order of :

RED
BLUE
GREEN

on the dedicted keyboard, all the operator has to do is press one of the keys first. Feedback to the input is given in the 'operation log'.

2.1.2. If wrong press 'DEL'ete key

If the wrong colour key was selected the operator can start again after first pressing the delete key which cancels the colour key.

2.1.3. Press '12' key

A numeric keypad of standard layout from 0 to 12 allows the operator to call up the graphs after the correct colour sub-tree has been pressed. Once the number has been pressed the search for the graph begins, and there is no opportunity to delete this request. There is however a keyboard buffer which enables the operator to type ahead. Feedback to the input is given in the 'operation log'.

2.1.4. Read graph value

The value appears as a point (denoted by an arrowhead) on a historical graph. All graphs appear in the bottom left hand corner of the screen, and are updated every few seconds. It may be necessary to examine all of them because more than one unit can be faulty.

2.2. Locate bottom level display containing fault

Once the colour sub-tree has been identified the operator has to locate the bottom level unit within the sub-tree.

2.2.1. Locate middle level group containing fault

The first stage of the sub-tree search is to identify within which middle level group the fault is contained, this will enable the operator to limit the number of possible alternatives to 3 bottom level display units from a possible 27.

Press identified 'colour' key

The colour keys are laid out in the order of :

RED
BLUE
GREEN

on the dedicted keyboard, all the operator has to do is press one of the keys first. Feedback to the input is given in the 'operation log'.

If wrong press 'DEL'ete key

If the wrong colour key was selected the operator can start again after first pressing the delete key which cancels the colour key.

Press 'number' key (either 9, 10, or 11)

A numeric keypad of standard layout from 0 to 12 allows the operator to call up the graphs after the correct colour sub-tree has been pressed. Once the number has been pressed the search for the graph begins, and there is no opportunity to delete this request. There is however a keyboard buffer which enables the operator to type ahead. Feedback to the input is given in the 'operation log'.

Read graph value

The value appears as a point (denoted by an arrowhead) on a historical graph. All graphs appear in the bottom left hand corner of the screen, and are updated every few seconds. It may be necessary to examine all of them because more than one unit can be faulty.

2.2.2. Locate bottom level display unit

By sequentially examining the 3 bottom level display units, the operator can identify the faulty one.

Press identified 'colour' key

The colour keys are laid out in the order of :

RED
BLUE
GREEN

on the dedicted keyboard, all the operator has to do is press one of the keys first. Feedback to the input is given in the 'operation log'.

If wrong press 'DEL'ete key

If the wrong colour key was selected the operator can start again after first pressing the delete key which cancels the colour key.

Press 'number' key (0-8 depending upon identified group)

A numeric keypad of standard layout from 0 to 12 allows the operator to call up the graphs after the correct colour sub-tree has been pressed. Once the number has been pressed the search for the graph begins, and there is no opportunity to delete this request. There is however a keyboard buffer which enables the operator to type ahead. Feedback to the input is given in the 'operation log'.

2.2.3. Reset fault

When the faulty unit has been identified the operator is required to reset it. This will automatically set this unit on its correct running course. To reset the unit the operator has to press the 'RESET' button which is located above the 'OUTPUT' button on the left hand side of the keyboard. After 'reseting' the faulty unit(s) the operator may return to monitor 'output' or return to another sub-tree that requires further investigation. Feedback to the input is given in the 'operation log'.

3. Identify alarms

As well as monitoring the 'output' and responding to deviations, the operator must also identify alarms and respond immediately if they appear. Alarms take priority over all other activities, which must cease if they occur.

3.1. Read graph value

The value appears as a point (denoted by an arrowhead) on a historical graph. All graphs appear in the bottom left hand corner of the screen, and are updated every few seconds.

3.2. Maintain vigilance for alarms

The operator should be vigilant for the occurance of alarms because of their importance, ignoring alarms is a serious contravention of operating procedure.

3.2.1. Occasionally scan panel for reverse video display

The alarm panel is located at the top of the screen, and by scanning it the operator should be able to identify an alarm by the panel highlighted with reverse video over the corresponding code of the faulty display unit.

3.2.2. Listen for alarm 'beep'

The operator should also be aware of the 'bleep' that accompanies the alarms first appearance on the panel. If this is missed then the panel scan should pick the alarm up.

3.3. Respond to alarm

It is imperative that the operator responds immediately to the alarm, which has a priority over everything else.

3.3.1. Identify unit code from panel

The alarm panel contains the code of every item in the 'plant' in a matrix format. The box containing the code of a faulty item assumes the reverse video format until the item is selected and 'reset'

3.3.2. Press identified 'colour' key

The colour keys are laid out in the order of :

RED
BLUE
GREEN

on the dedicted keyboard, all the operator has to do is press one of the keys first. Feedback to the input is given in the 'operation log'.

3.3.3. If wrong press 'DEL'ete key

If the wrong colour key was selected the operator can start again after first pressing the delete key which cancels the colour key.

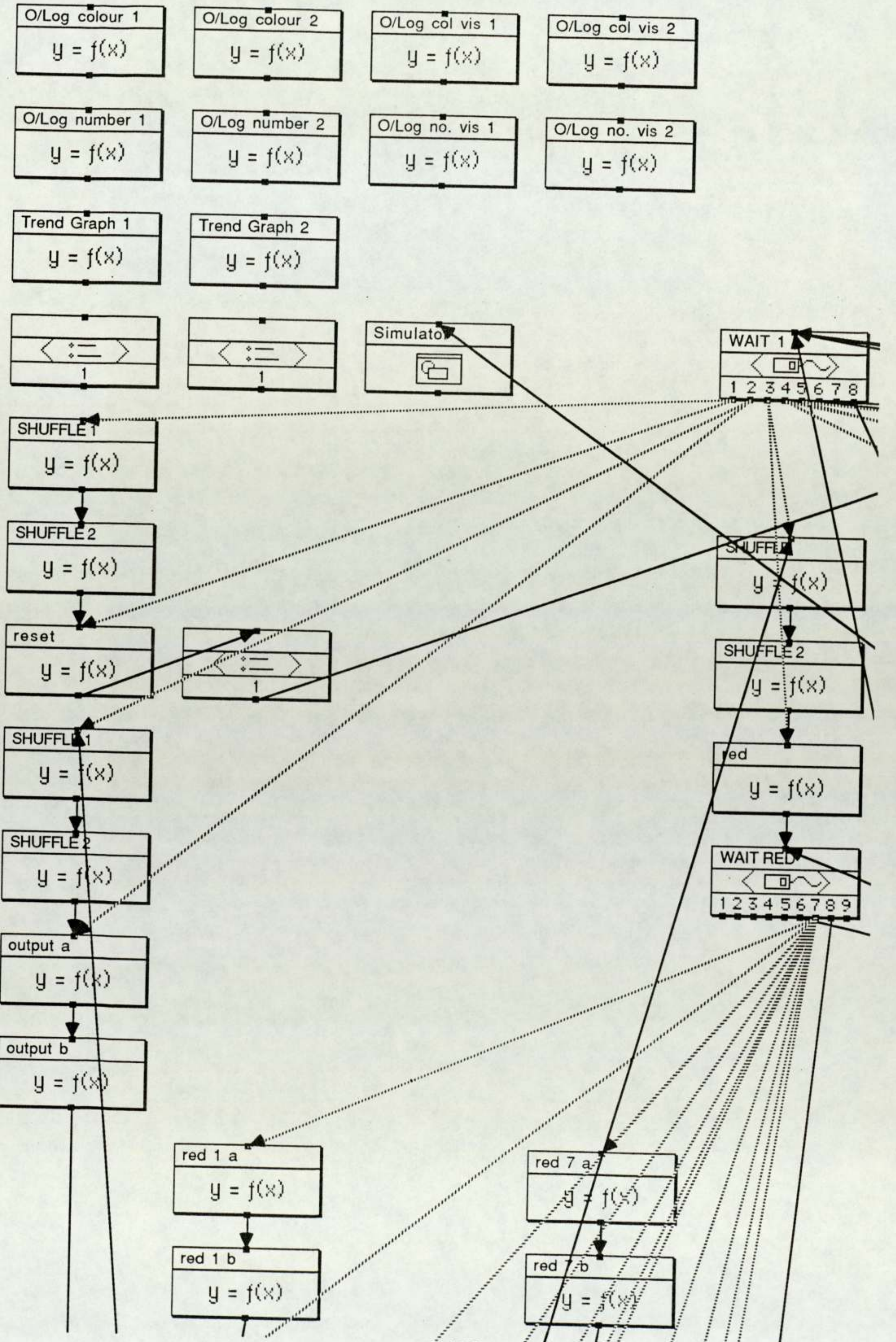
3.3.4. Press identified 'number' key

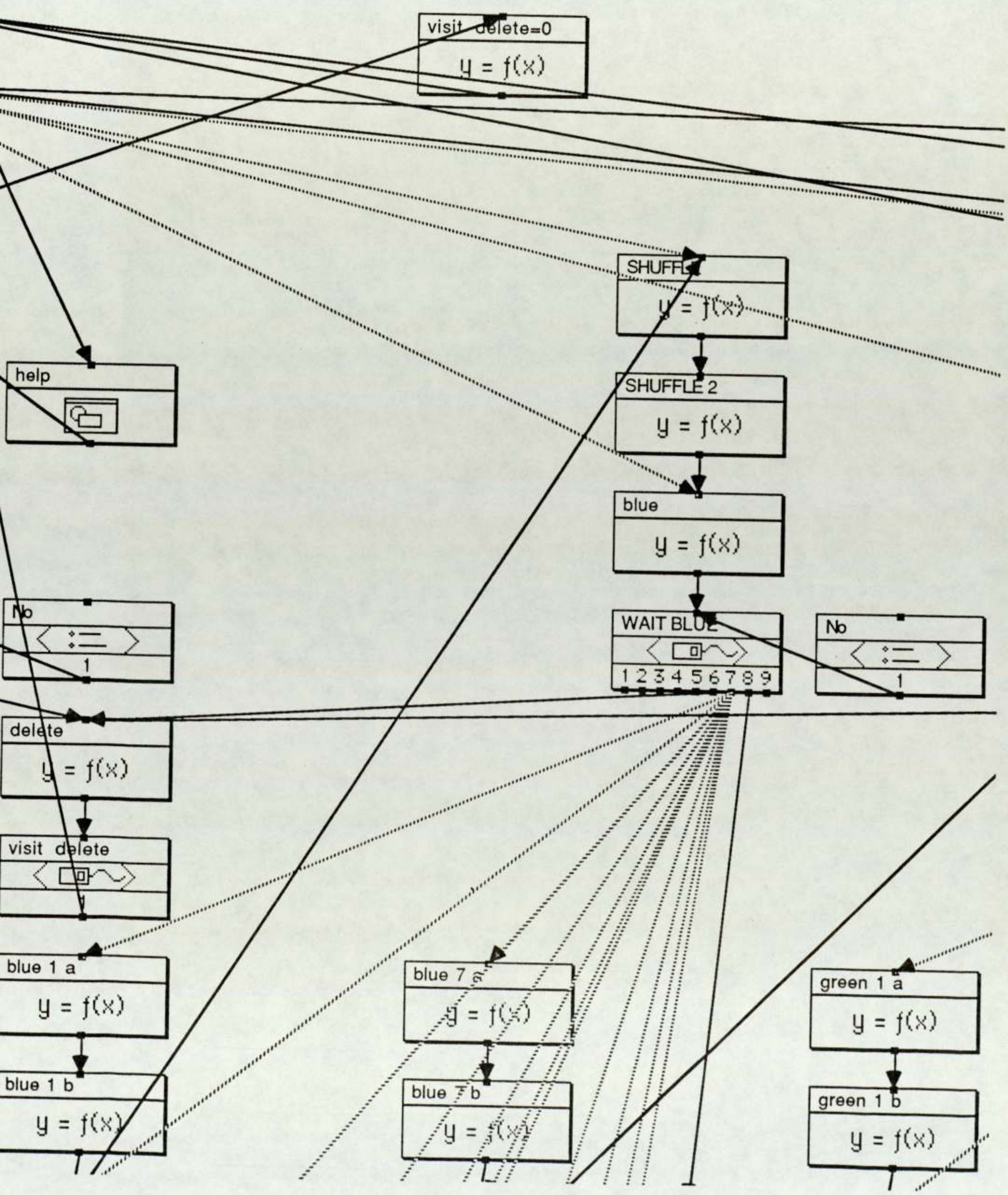
A numeric keypad of standard layout from 0 to 12 allows the operator to call up the graphs after the correct colour sub-tree has been pressed. Once the number has been pressed the search for the graph begins, and there is no opportunity to delete this request. There is however a keyboard buffer which enables the operator to type ahead. Feedback to the input is given in the 'operation log'.

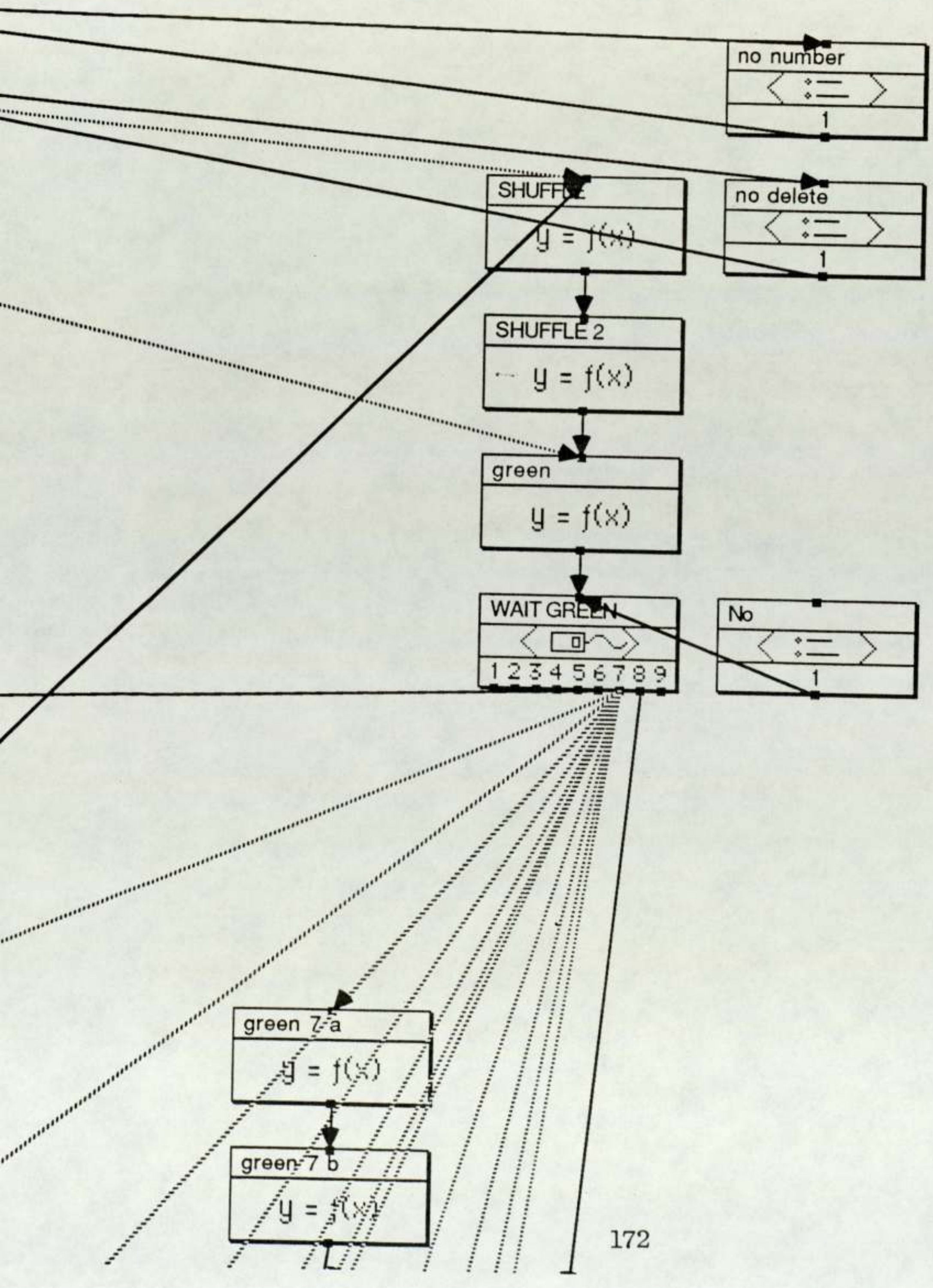
3.4. Reset fault

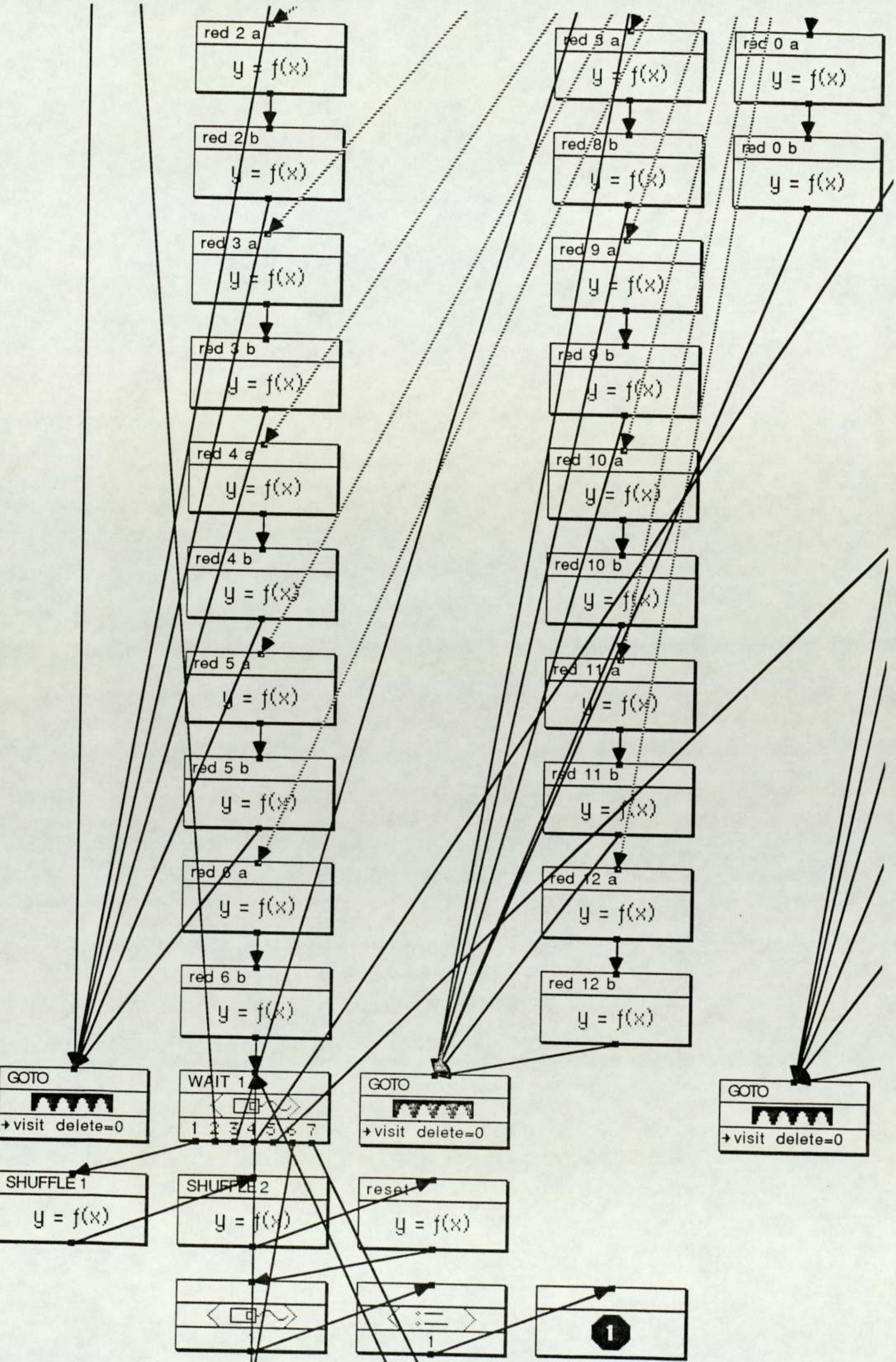
When the faulty unit has been identified the operator is required to reset it. This will automatically set this unit on its correct running course. To reset the unit the operator has to press the 'RESET' button which is located above the 'OUTPUT' button on the left hand side of the keyboard. Feedback to the input is given in the 'operation log'.

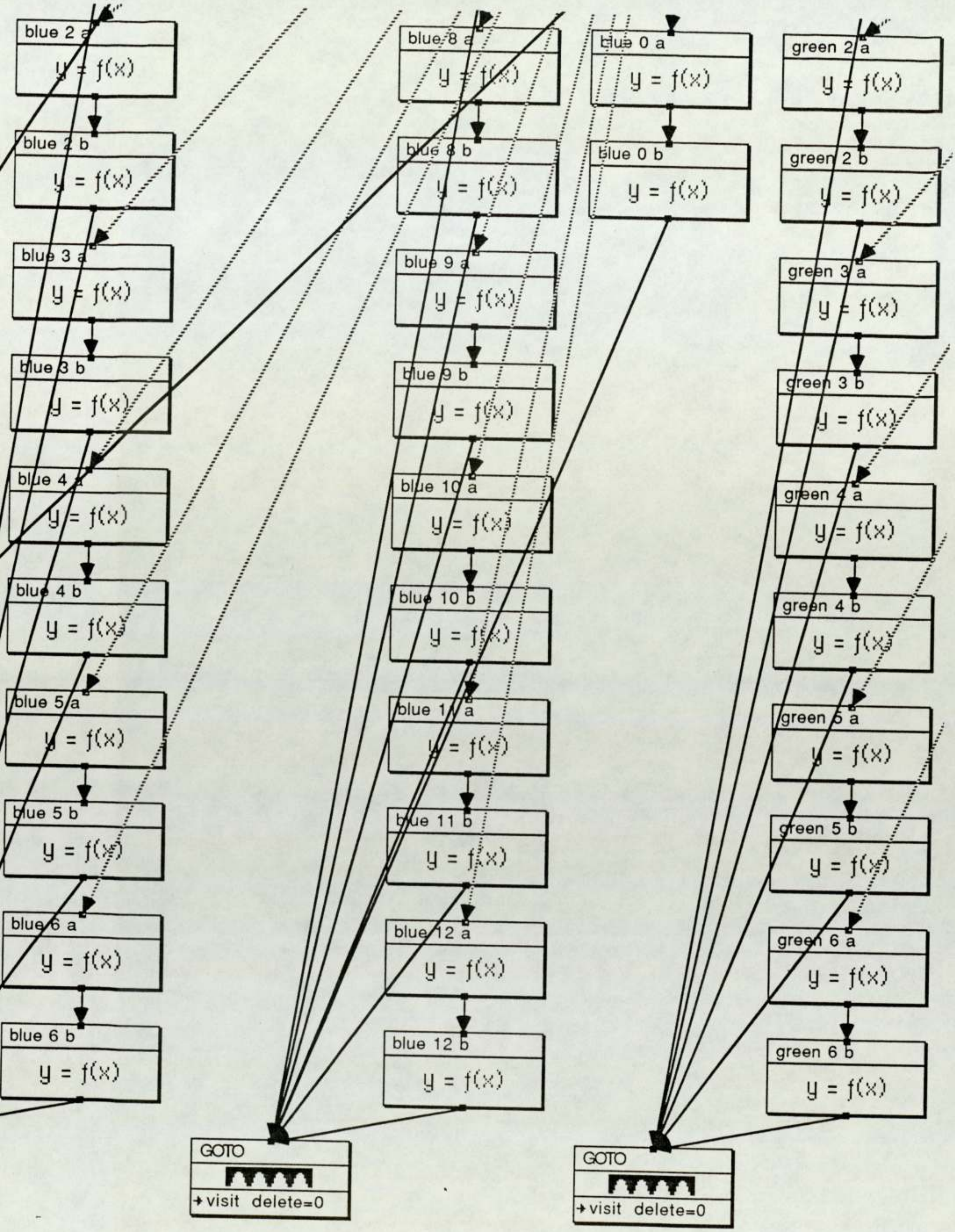
Appendix 3. Construction of Simulator in Coursebuilder™


O/Log colour 1
O/Log colour 2
O/Log col vis 1
O/Log col vis 2
O/Log number 1
O/Log number 2
O/Log no. vis 1
O/Log no. vis 2
Trend Graph 1
Trend Graph 2
Simulator
WAIT 1
SHUFFLE 1
SHUFFLE 2
reset
SHUFFLE 1
SHUFFLE 2
output a
output b
SHUFFLE 2
red
WAIT RED
red 1 a
red 1 b
red 7 a
red 7 b

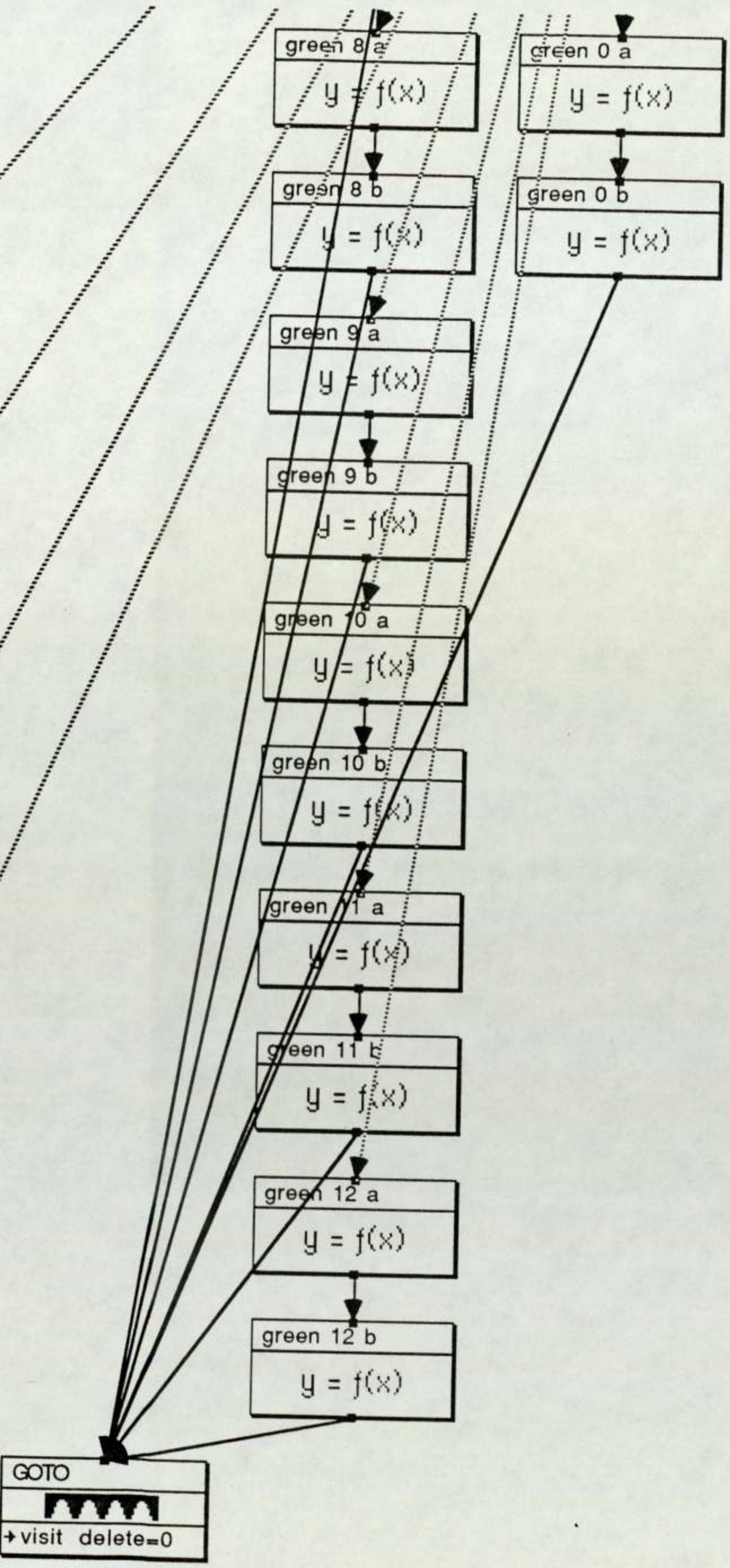

visit delete=0
y = f(x)
SHUFFLE
y = f(x)
SHUFFLE 2
y = f(x)
help
blue
y = f(x)
No
1
WAIT BLUE
1 2 3 4 5 6 7 8 9
No
1
delete
y = f(x)
visit delete
1
blue 1 a
y = f(x)
blue 7 a
y = f(x)
green 1 a
y = f(x)
blue 1 b
y = f(x)
blue 7 b
y = f(x)
green 1 b
y = f(x)

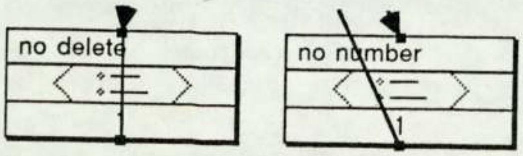

no number
1
SHUFFLE
y = f(x)
no delete
1
SHUFFLE 2
y = f(x)
green
y = f(x)
WAIT GREEN
1 2 3 4 5 6 7 8 9
No
1
green 7 a
y = f(x)
green 7 b
y = f(x)


red 2 a
y = f(x)
red 2 b
y = f(x)
red 3 a
y = f(x)
red 3 b
y = f(x)
red 4 a
y = f(x)
red 4 b
y = f(x)
red 5 a
y = f(x)
red 5 b
y = f(x)
red 6 a
y = f(x)
red 6 b
y = f(x)
red 8 a
y = f(x)
red 8 b
y = f(x)
red 9 a
y = f(x)
red 9 b
y = f(x)
red 10 a
y = f(x)
red 10 b
y = f(x)
red 11 a
y = f(x)
red 11 b
y = f(x)
red 12 a
y = f(x)
red 12 b
y = f(x)
red 0 a
y = f(x)
red 0 b
y = f(x)
GOTO
visit delete=0
WAIT 1
1 2 3 4 5 6 7
GOTO
visit delete=0
GOTO
visit delete=0
SHUFFLE 1
y = f(x)
SHUFFLE 2
y = f(x)
reset
y = f(x)
1
1
1

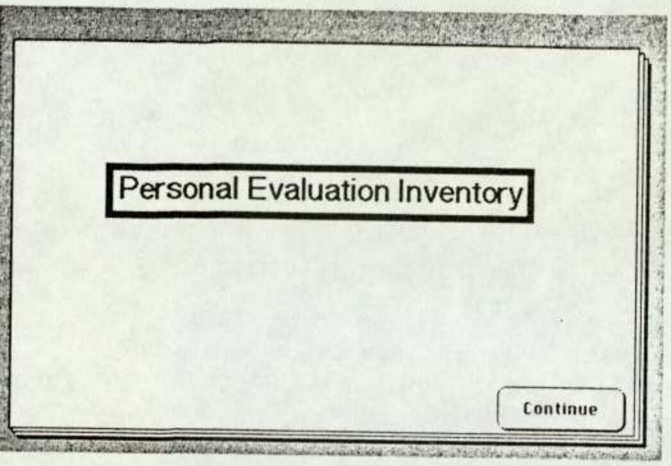


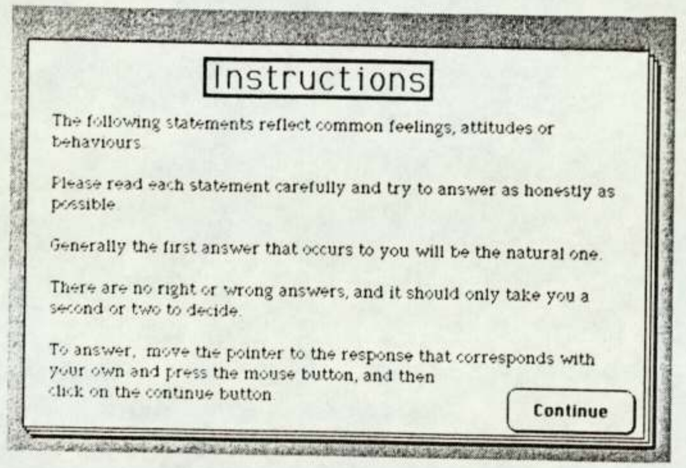
blue 2 a
y = f(x)
blue 2 b
y = f(x)
blue 3 a
y = f(x)
blue 3 b
y = f(x)
blue 4 a
y = f(x)
blue 4 b
y = f(x)
blue 5 a
y = f(x)
blue 5 b
y = f(x)
blue 6 a
y = f(x)
blue 6 b
y = f(x)
blue 8 a
y = f(x)
blue 8 b
y = f(x)
blue 9 a
y = f(x)
blue 9 b
y = f(x)
blue 10 a
y = f(x)
blue 10 b
y = f(x)
blue 11 a
y = f(x)
blue 11 b
y = f(x)
blue 12 a
y = f(x)
blue 12 b
y = f(x)
GOTO
visit delete=0
blue 0 a
y = f(x)
blue 0 b
y = f(x)
GOTO
visit delete=0
green 2 a
y = f(x)
green 2 b
y = f(x)
green 3 a
y = f(x)
green 3 b
y = f(x)
green 4 a
y = f(x)
green 4 b
y = f(x)
green 5 a
y = f(x)
green 5 b
y = f(x)
green 6 a
y = f(x)
green 6 b
y = f(x)

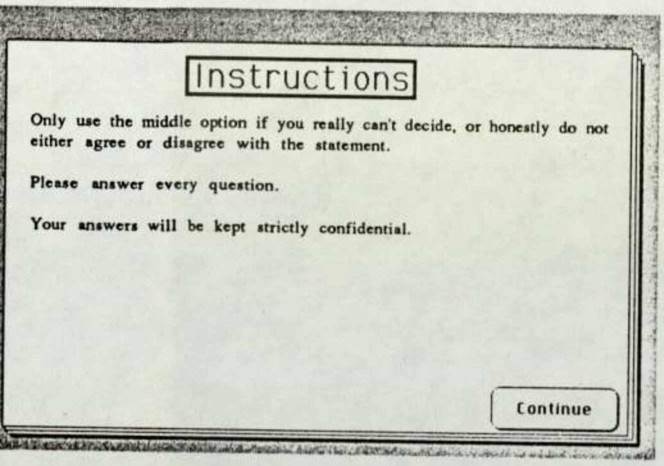

green 8 a
y = f(x)
green 8 b
y = f(x)
green 9 a
y = f(x)
green 9 b
y = f(x)
green 10 a
y = f(x)
green 10 b
y = f(x)
green 11 a
y = f(x)
green 11 b
y = f(x)
green 12 a
y = f(x)
green 12 b
y = f(x)
green 0 a
y = f(x)
green 0 b
y = f(x)
GOTO
visit delete=0

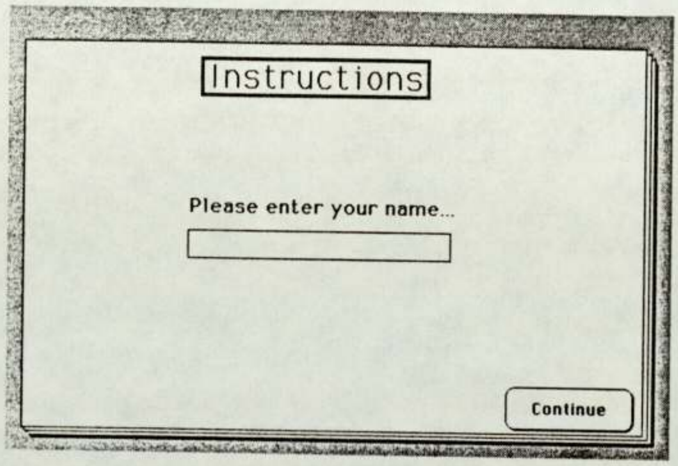

no delete
no number
1

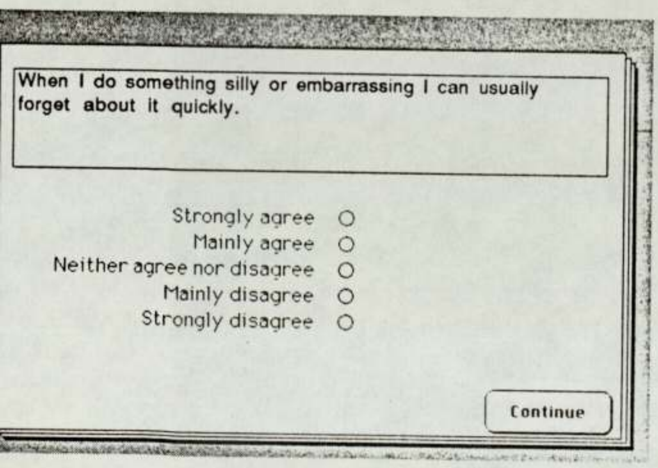
Appendix 4. Self Confidence Questionnaire in HyperCard

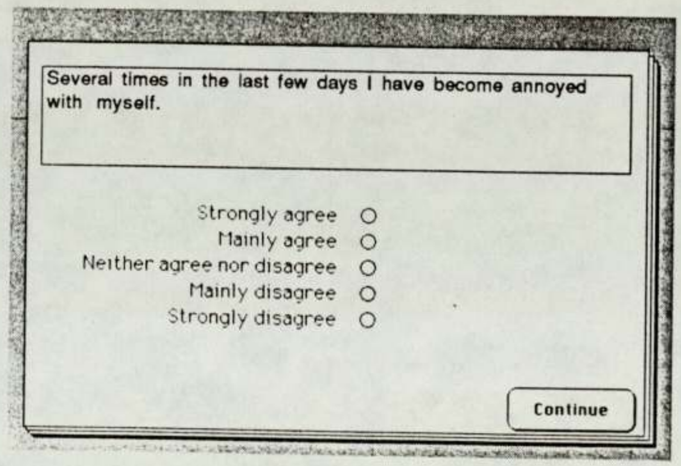

Personal Evaluation Inventory
Continue

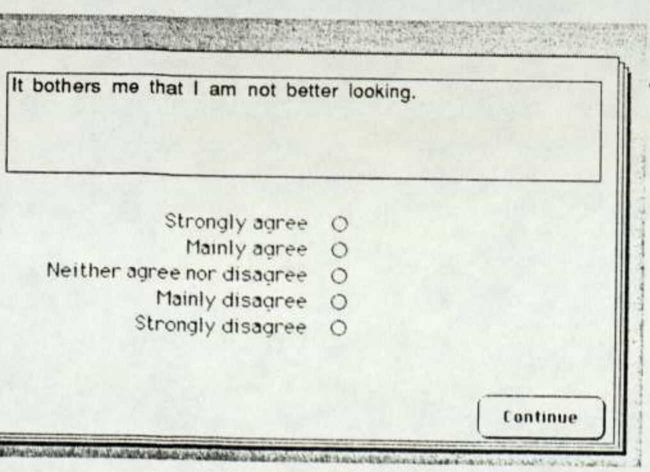

Instructions
The following statements reflect common feelings, attitudes or behaviours.
Please read each statement carefully and try to answer as honestly as possible.
Generally the first answer that occurs to you will be the natural one.
There are no right or wrong answers, and it should only take you a second or two to decide.
To answer, move the pointer to the response that corresponds with your own and press the mouse button, and then click on the continue button.
Continue

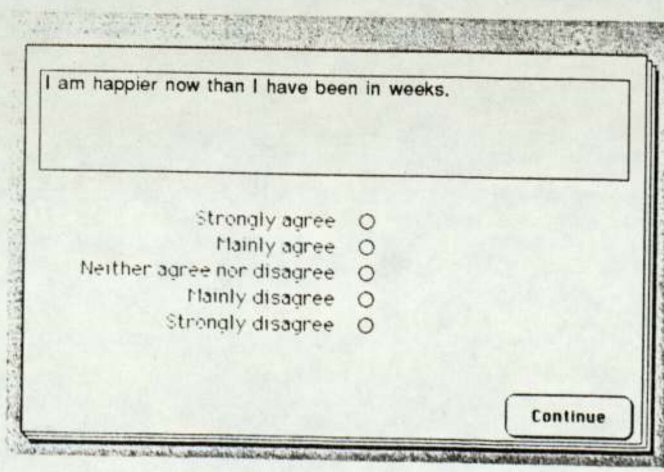

Instructions
Only use the middle option if you really can't decide, or honestly do not either agree or disagree with the statement.
Please answer every question.
Your answers will be kept strictly confidential.
Continue


Instructions
Please enter your name...
Continue


When I do something silly or embarrassing I can usually forget about it quickly.
Strongly agree
Mainly agree
Neither agree nor disagree
Mainly disagree
Strongly disagree
Continue


Several times in the last few days I have become annoyed with myself.
Strongly agree
Mainly agree
Neither agree nor disagree
Mainly disagree
Strongly disagree
Continue


It bothers me that I am not better looking.
Strongly agree
Mainly agree
Neither agree nor disagree
Mainly disagree
Strongly disagree
Continue


I am happier now than I have been in weeks.
Strongly agree
Mainly agree
Neither agree nor disagree
Mainly disagree
Strongly disagree
Continue

I am pleased with my physical appearance.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I sometimes avoid taking part in ball games and informal sports activities because I don't think I am good enough at them.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

Talking in front of a group makes me uncomfortable.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I would like to know more people, but am reluctant to go out and meet them.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

Athletics is an area in which I excel.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

Academic performance is an area in which I can show my competence and be recognized for my achievement.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

In the last day or two some things have happened that have made me question my own capabilities more than I usually do.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I possess the qualities that really matter in life.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am better looking than the average person.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I dread the thought of getting up and talking in public.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

Much of the time I don't feel that I am as competent as I should be.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I frequently wonder whether I have the intellectual ability to successfully achieve my vocational and academic goals.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

Often I find myself going along with other people's opinions even if they are not better than my own.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

When I think about playing most sports I am enthusiastic and eager rather than apprehensive and anxious.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

In the past couple of days some things have happened that made me feel particularly good about myself.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am happy being the person I am.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am a better athlete than most people of my own age and sex.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I feel that I constantly have to prove myself to gain other people's respect.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I am uncomfortable in many situations because I am uncertain about my abilities.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

When I have to talk before a group of people I usually feel assured that I can express myself effectively and clearly.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I am fortunate to be as good looking as I am.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I have recognised that I am not as good a student as most of the people I am competing with.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I have been more critical of myself in the last few days than I usually am.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

Being poor at sports is an important weakness of mine.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

For me, meeting new people is an enjoyable experience that I look forward to.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

At least once or twice a week I feel I am not the sort of person I would like to be.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I can think of at least two important areas in my life in which I frequently feel that I lack the ability needed to be successful.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I almost never feel uncomfortable at parties or other social gatherings.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

It bothers me that I don't measure up to others intellectually.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I have little difficulty making friends.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

When I face a stressful situation I usually feel that I can deal with it effectively.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I am basically a good person.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I am more concerned than most people about my ability to speak in public.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am not happy with the way I am leading my life.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I have more confidence in myself than most people I know.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I have never avoided taking part in an activity because I felt I might fail at it.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

Most people would probably consider me physically unnatractive.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

When I take a new course I am usually sure that I will end up in the top 25% of the class.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am as capable as most people at speaking before a group.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

My family does not approve of me.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I like myself.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

When I go to social gatherings I frequently feel awkward and ill at ease.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am at least as good looking as most people I know.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I have sometimes avoided taking classes or doing other things because they would require my making presentations before a group.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

When I have to come through on important tests or other academic assignments, I know I can do it.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I have little difficulty making friends

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I feel more confident about myself today than I usually do.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I wish I could change my physical appearance.

Strongly agree ○
Mainly agree ○
Neither agree nor disagree ○
Mainly disagree ○
Strongly disagree ○

Continue

I am less concerned than most people about speaking in public.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I shy away from some activities because they seem too intellectually demanding.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I can think of several groups of people that I avoid because I don't know how to act around them.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

Right now I am feeling more optimistic and positive than usual.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

Attracting a desirable partner has never been a problem for me.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I don't hesitate to express my ideas in front of a group.

- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue

I seek out activities that are intellectually challenging because I know I can do them better than most people.

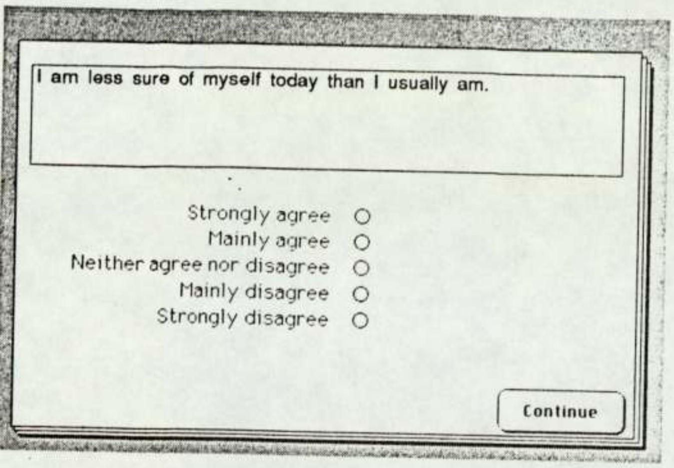
- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

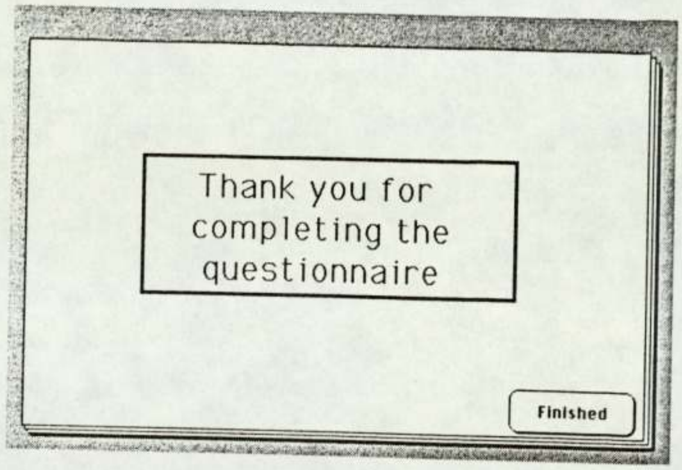
Continue

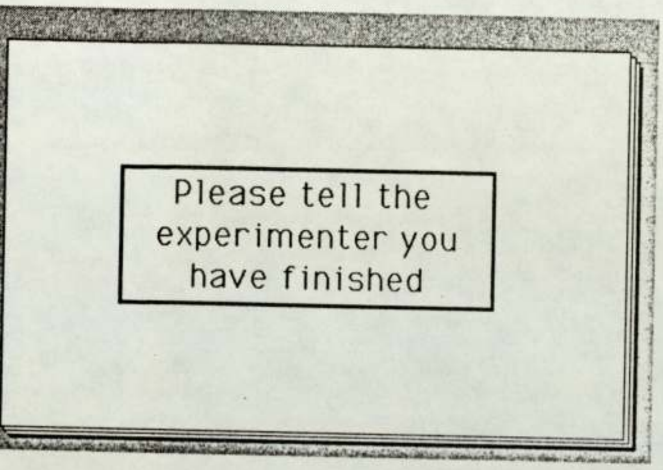
I have more good friends than most people.

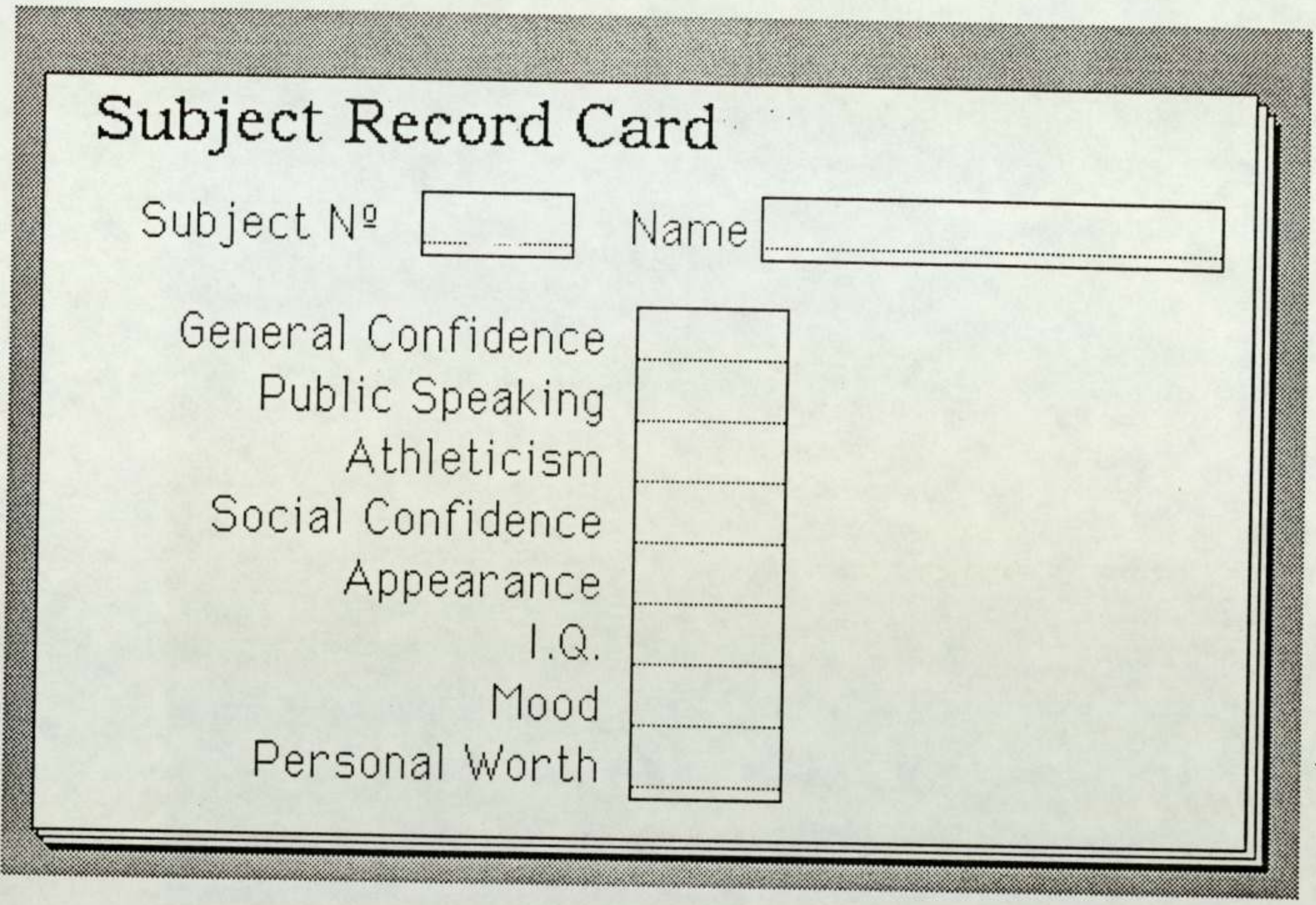
- Strongly agree ○
- Mainly agree ○
- Neither agree nor disagree ○
- Mainly disagree ○
- Strongly disagree ○

Continue


I am less sure of myself today than I usually am.
Strongly agree
Mainly agree
Neither agree nor disagree
Mainly disagree
Strongly disagree
Continue


Thank you for completing the questionnaire
Finished


Please tell the experimenter you have finished



Appendix 5. Subject Record Card in HyperCard

t Opinion Questionnaire A

at did you find constrained you in the training?

ere you ever lost during the navigation of the training sessions?

difficult did you find the training meduim?

useful did you find the training?

you find the training interesting?

ld you have preferred to have received the training by:

x	YES/NO
onstration	YES/NO
ure	YES/NO
r?	

ere anything you would like to add

Appendix 6. Subject Opinion Questionnaire A

Appendix 7:

Subject Opinion Questionnaire B

1. What did you find constrained you in the training?

2. Where you ever lost during the navigation of the training sessions?

3. How difficult did you find the training meduim?

4. How useful did you find the training?

5. Did you find the training interesting?

6. Would you have preferred to have received the training by:

Book	YES/NO
Demonstration	YES/NO
Lecture	YES/NO
Other?	

7a. Did you view all of the learn and practice sessions?

YES/NO (if NO then please go to 7b, else go to 8)

7b. If NO to 7a then which ones did you not see?

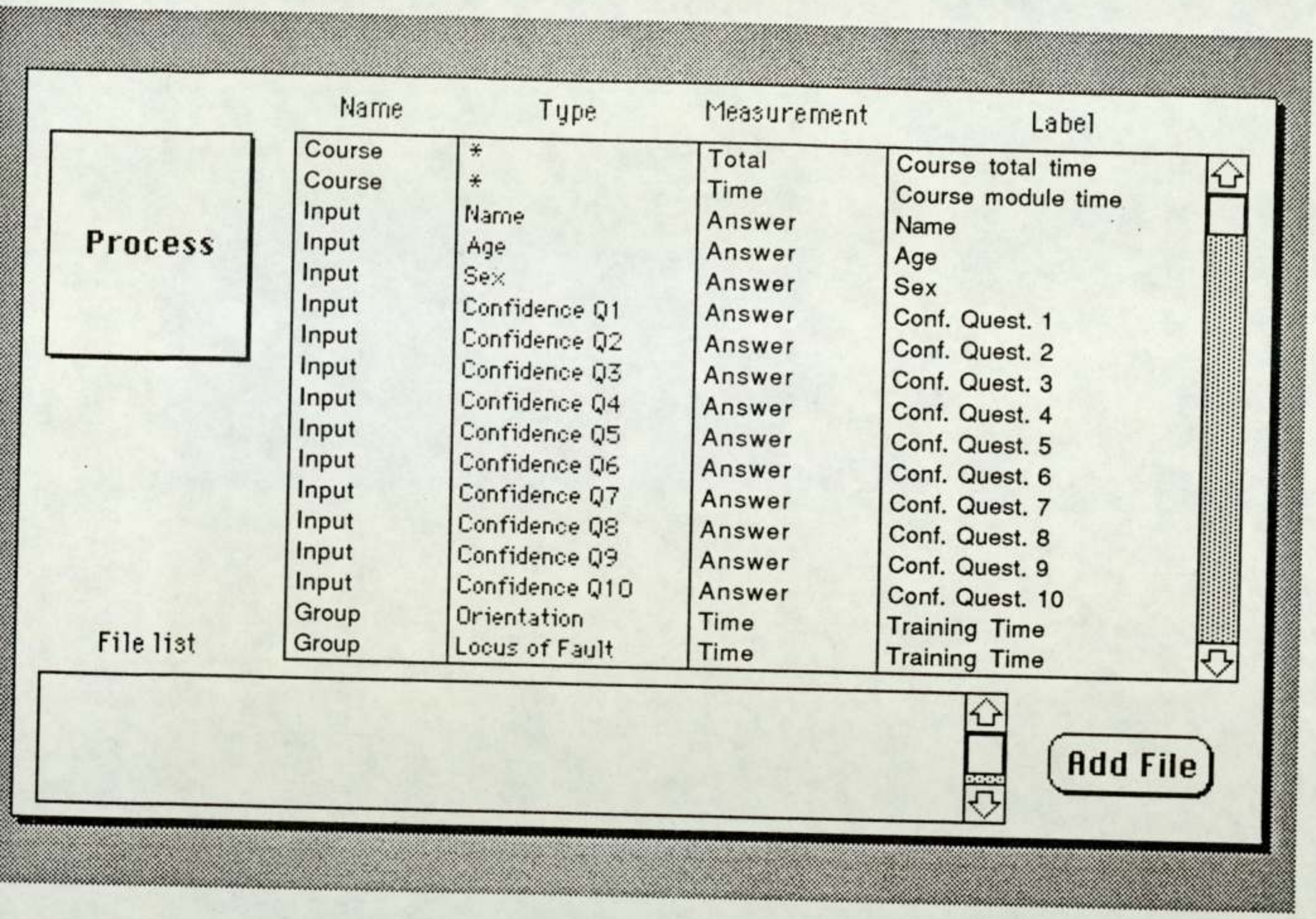
7c. If NO to 7a then why?

8. Please rank order the sessions as you viewed them...

Fault Location	Learn	Practice
Alarm Action	Learn	Practice
Monitor Plant	Learn	Practice
Screen Layout	Learn	Practice
Keyboard Layout	Learn	Practice
Delete Funtion	Learn	Practice
Layout of Monitors	Learn	Practice

9. Did you find the "Tell me more about..." function useful?

10. Is there anything you would like to add (please use the reverse of this form)?



Appendix 8. Course Report Analyser in HyperCard

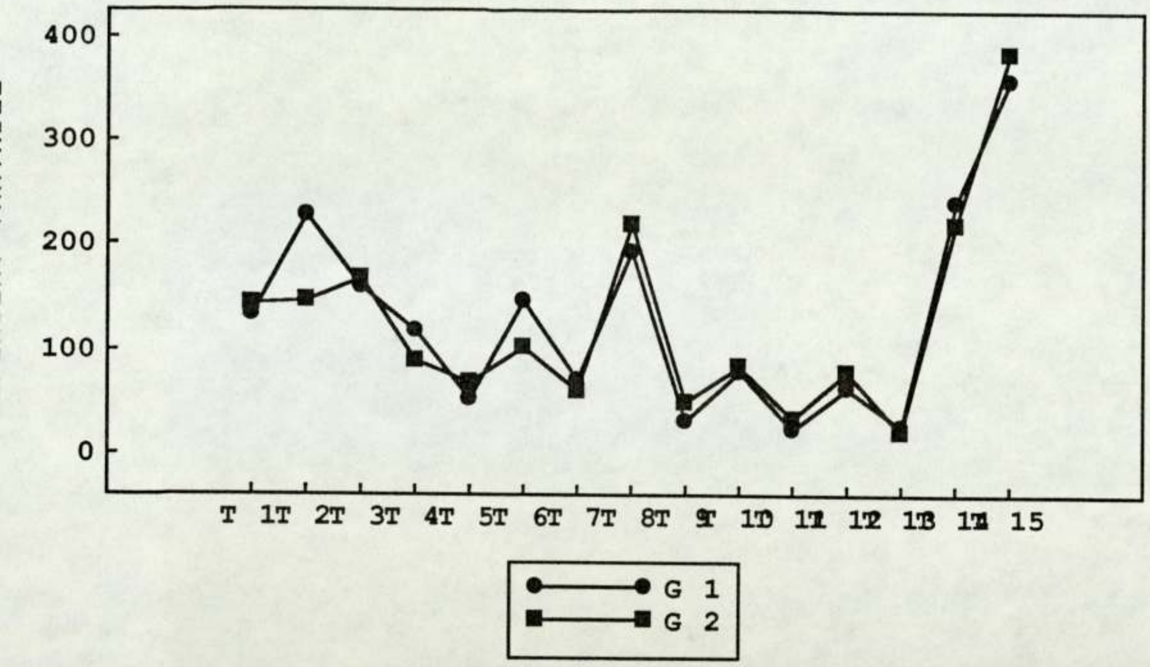
Appendix 9. Linear & Non-Linear Data

ANOVA Summary Table for Nev 4 (M.Phil.):DATA:L/NL_Trainingtime

Source of Variation	df	Sum of Squares	Mean Square	F	p	Epsilon Correction
G	1	2258.160	2258.160	.193	.6630	
Error	38	444815.573	11705.673			
T	14	4921578.583	351541.327	46.156	.0000	
GT	14	119775.090	8555.364	1.123	.3338	
Error	532	4051905.927	7616.365			.17

Appendix 9.9. Training Time

ect	MSn	DFn	DFe	MSe	F	p
at T 1	714.025	1	38	1642.141	.435	.514
at T 2	64561.225	1	38	4789.941	13.479	.001
at T 3	378.225	1	38	23601.941	.016	.900
at T 4	8294.400	1	38	1250.200	6.634	.014
at T 5	2325.625	1	38	1648.283	1.411	.242
at T 6	20385.225	1	38	2482.372	8.212	.007
at T 7	722.500	1	38	2012.661	.359	.553
at T 8	6553.600	1	38	2467.421	2.656	.111
at T 9	4100.625	1	38	526.557	7.788	.008
at T 10	140.625	1	38	1328.562	.106	.747
at T 11	1081.600	1	38	203.166	5.324	.027
at T 12	2640.625	1	38	958.846	2.754	.105
at T 13	403.225	1	38	502.993	.802	.376
at T 14	3802.500	1	38	5689.753	.668	.419
at T 15	5929.225	1	38	69229.941	.086	.771
at G 1	182052.463	14	532	7616.365	23.903	.000
at G 2	178044.228	14	532	7616.365	23.377	.000


400
300
200
100
0
T 1T 2T 3T 4T 5T 6T 7T 8T 9T 10 11 12 13 14 15
G 1
G 2

	Group	Mod Compl.	Repeats	Not Done	Train Time	Mod/Time	Transfer	Retention
1	Non-L...	10	1	6	2156.38	215.64	772.00	702.00
2	Non-L...	14	1	2	2730.35	195.02	1785.00	1865.00
3	Non-L...	11	0	4	1864.27	169.48	1586.00	896.00
4	Non-L...	14	5	6	2356.90	168.35	1477.00	952.00
5	Non-L...	13	3	4	2415.80	185.83	2216.00	1108.00
6	Non-L...	14	0	2	3193.38	228.10	1130.00	745.00
7	Non-L...	16	1	0	2734.07	170.88	1270.00	599.00
8	Non-L...	14	1	2	2890.75	206.48	4995.00	717.00
9	Non-L...	15	3	3	3289.62	219.31	1819.00	865.00
10	Non-L...	16	1	0	2935.37	183.46	1949.00	878.00
11	Non-L...	14	0	1	2931.17	209.37	2203.00	2150.00
12	Non-L...	15	0	0	3464.08	230.94	2270.00	901.00
13	Non-L...	16	3	2	2587.58	161.72	1549.00	810.00
14	Non-L...	11	1	4	1853.13	168.47	1252.00	847.00
15	Non-L...	15	0	1	2917.82	194.52	2759.00	888.00
16	Non-L...	18	3	0	3090.17	171.68	2680.00	1272.00
17	Non-L...	15	2	2	2521.53	168.10	2651.00	815.00
18	Non-L...	18	3	0	2890.75	160.60	4995.00	1460.00
19	Non-L...	16	2	2	2080.22	130.01	1141.00	1415.00
20	Non-L...	13	10	1	3325.42	255.80	1690.00	1169.00
21	Linear	17	2	0	2899.33	170.55	15497.00	5066.00
22	Linear	15	0	0	2465.58	164.37	4348.00	5612.00
23	Linear	16	1	0	2802.98	175.19	2290.00	1868.00
24	Linear	15	0	0	2171.63	144.78	2498.00	1572.00
25	Linear	15	0	0	2877.25	191.82	2167.00	995.00
26	Linear	16	1	0	2490.88	155.68	2232.00	1684.00
27	Linear	16	1	0	2729.57	170.60	3480.00	3503.00
28	Linear	15	0	0	2743.63	182.91	1542.00	1167.00

Appendix 9.2. Overall Data

	Group	Mod Compl.	Repeats	Not Done	Train Time	Mod/Time	Transfer	Retention
30	Linear	15	0	0	1932.72	128.85	8544.00	1163.00
31	Linear	16	1	0	2784.93	174.06	9996.00	1323.00
32	Linear	15	0	0	2104.27	140.28	568.00	632.00
33	Linear	15	0	0	1909.22	127.28	1935.00	1265.00
34	Linear	15	0	0	3025.78	201.72	2619.00	1192.00
35	Linear	15	0	0	2105.53	140.37	3218.00	1227.00
36	Linear	15	0	0	2655.55	177.04	1791.00	1016.00
37	Linear	15	0	0	2188.98	145.93	2706.00	1681.00
38	Linear	16	1	0	2647.12	165.44	10418.00	1317.00
39	Linear	16	1	0	1830.00	114.38	931.00	703.00
40	Linear	15	0	0	3005.28	200.35	2835.00	988.00

One Factor ANOVA X_1: Group Y_1: Train Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	579608.033	579608.033	3.026
Within groups	38	7278426.372	191537.536	p = .09
Total	39	7858034.405		

Model II estimate of between component variance = 388070.496

1

One Factor ANOVA X_1: Group Y_1: Train Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Linear	20	2470.688	396.92	88.754
Non-Linear	20	2711.438	474.899	106.191

2

One Factor ANOVA X_1: Group Y_1: Train Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Linear vs. Non-Linear	-240.75	280.199	3.026	1.74

3

Appendix 9.2.1. Parametric Analyses

One Factor ANOVA X_1: Group Y_2: Mod/Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	8583.17	8583.17	11.122
Within groups	38	29324.617	771.7	p = .0019
Total	39	37907.787		

Model II estimate of between component variance = 7811.469

4

One Factor ANOVA X_1: Group Y_2: Mod/Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Linear	20	160.391	24.925	5.573
Non-Linear	20	189.688	30.367	6.79

5

One Factor ANOVA X_1: Group Y_2: Mod/Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Linear vs. Non-Linear	-29.297	17.785*	11.122*	3.335

* Significant at 95%

6

One Factor ANOVA X_1: Group Y_3: Transfer

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	38716465.225	38716465.225	4.71
Within groups	38	312385540.75	8220672.125	p = .0363
Total	39	351102005.975		

Model II estimate of between component variance = 30495793.1

7

One Factor ANOVA X_1: Group Y_3: Transfer

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Linear	20	4077.1	3894.266	870.784
Non-Linear	20	2109.45	1129.618	252.59

8

One Factor ANOVA X_1: Group Y_3: Transfer

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Linear vs. Non-Linear	1967.65	1835.664*	4.71*	2.17

* Significant at 95%

9

One Factor ANOVA X_1: Group Y_4: Retention

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	4860181.225	4860181.225	4.791
Within groups	38	38547354.75	1014404.072	p = .0348
Total	39	43407535.975		

Model II estimate of between component variance = 3845777.153

10

One Factor ANOVA X_1: Group Y_4: Retention

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Linear	20	1749.85	1366.461	305.55
Non-Linear	20	1052.7	401.985	89.886

11

One Factor ANOVA X_1: Group Y_4: Retention

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Linear vs. Non-Linear	697.15	644.83*	4.791*	2.189

* Significant at 95%

12

Anova table for a 2-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Group (A)	1	35505795.2	35505795.2	6.035	.0187
subjects w. groups	38	223561491.75	5883197.151		
Repeated Measure (B)	1	57257280	57257280	17.082	.0002
AB	1	8070851.25	8070851.25	2.408	.129
B x subjects w. groups	38	127371403.75	3351879.046		

There were no missing cells found.

1

The AB Incidence table

Repeated Mea...		Transfer	Retention	Totals:
Group	Linear	20 4077.1	20 1749.85	40 2913.475
	Non-Linear	20 2109.45	20 1052.7	40 1581.075
Totals:		40 3093.275	40 1401.275	80 2247.275

2

Mann-Whitney U X_1: Group Y_1: Mod Compl.

	Number:	Σ Rank:	Mean Rank:
Linear	20	480	24
Non-Linear	20	340	17

U	130
U-prime	270
Z	-1.894
Z corrected for ties	-1.99
# tied groups	6

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
Linear	20	302.5	15.125
Non-Linear	20	517.5	25.875

U	92.5
U-prime	307.5
Z	-2.908
Z corrected for ties	-3.1
# tied groups	4

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
Linear	20	260	13
Non-Linear	20	560	28

U	50
U-prime	350
Z	-4.058
Z corrected for ties	-4.679
# tied groups	5

3

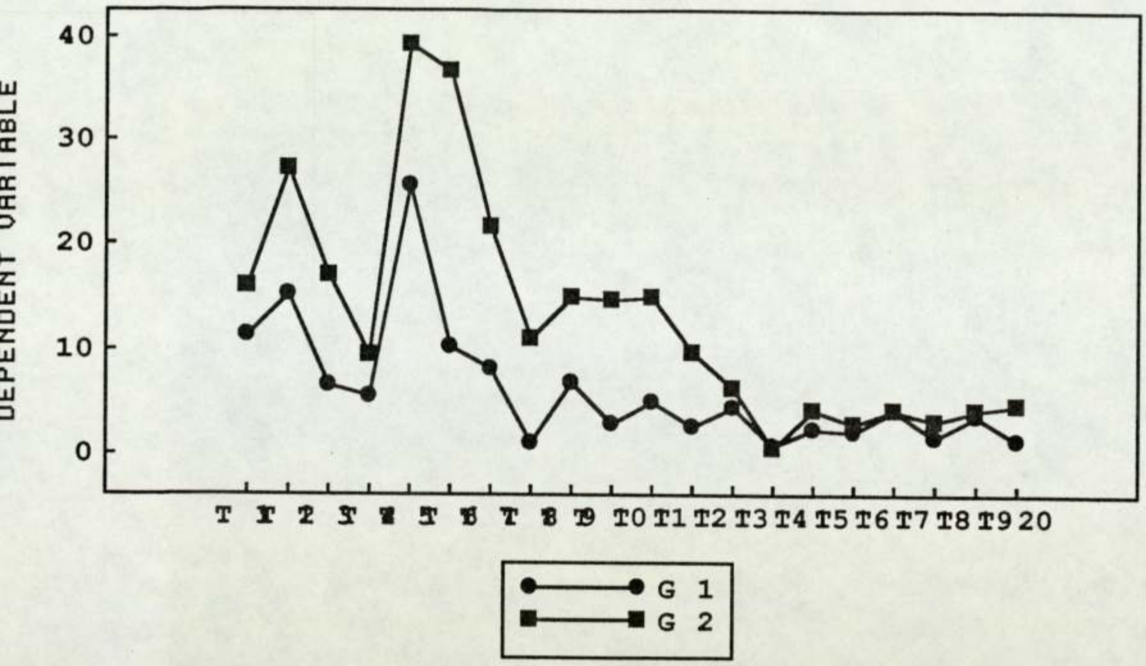
Appendix 9.2.2. Non-Parametric Analyses

ANOVA Summary Table for Nev 4 (M.Phil.):DATA:NL/L(points)

Source of Variation	df	Sum of Squares	Mean Square	F	p	Epsilon Correction
G	1	9835.031	9835.031	5.408	.0255	
Error	38	69107.518	1818.619			
T	19	50524.674	2659.193	15.701	.0000	
GT	19	8326.744	438.250	2.588	.0002	
Error	722	122278.433	169.361			.14

Appendix 9.3.
Transfer Performance Data

ect	MSn	DFn	DFe	MSe	F	p
at T 1	216.225	1	38	74.030	2.921	.096
at T 2	1404.225	1	38	414.462	3.388	.073
at T 3	1060.900	1	38	326.816	3.246	.080
at T 4	164.025	1	38	103.799	1.580	.216
at T 5	1863.225	1	38	349.462	5.332	.026
at T 6	6969.600	1	38	1734.008	4.019	.052
at T 7	1822.500	1	38	699.774	2.604	.115
at T 8	990.025	1	38	245.362	4.035	.052
at T 9	672.400	1	38	133.663	5.031	.031
at T 10	1380.625	1	38	231.351	5.968	.019
at T 11	940.900	1	38	237.321	3.965	.054
at T 12	469.225	1	38	255.399	1.837	.183
at T 13	40.000	1	38	57.832	.692	.411
at T 14	1.225	1	38	1.425	.860	.360
at T 15	27.225	1	38	6.151	4.426	.042
at T 16	6.400	1	38	45.158	.142	.709
at T 17	.100	1	38	27.784	.004	.952
at T 18	18.225	1	38	16.699	1.091	.303
at T 19	2.500	1	38	20.879	.120	.731
at T 20	112.225	1	38	55.099	2.037	.162
at G 1	702.484	19	722	169.361	4.148	.000
at G 2	2394.959	19	722	169.361	14.141	.000



DEPENDENT VARIABLE
40
30
20
10
0
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20
G 1
G 2

6	0	0	14	5	2	5	1	5	8	0	8	0	2	0	0
0	0	6	1	22	0	2	0	8	0	0	0	11	0	4	0
0	11	5	0	22	17	2	0	8	2	11	0	0	0	0	8
17	38	26	34	70	91	20	0	11	2	4	0	0	5	0	0
6	11	6	9	17	0	2	0	0	8	5	0	0	0	0	8
0	0	6	1	17	0	5	0	8	0	0	8	0	0	4	0
17	38	0	12	20	0	11	0	2	0	4	0	0	0	0	8
22	26	5	0	32	0	14	0	4	14	0	13	8	0	4	0
2	11	0	0	45	17	2	0	8	0	6	0	0	0	5	0
2	11	5	1	17	0	8	0	8	5	11	0	0	0	0	4
17	10	0	1	8	0	8	0	5	0	6	0	8	0	4	0
17	33	6	1	28	0	14	0	8	0	2	0	11	0	5	0
17	11	6	0	28	0	8	0	5	0	6	0	11	0	4	0
17	11	5	0	25	17	14	0	8	0	2	13	11	0	4	0
17	33	6	0	34	20	8	14	8	2	6	0	11	0	5	0
30	11	0	15	11	1	0	2	0	0	0	5	0	4	0	0
6	0	6	9	23	0	8	0	8	2	11	0	0	0	0	4
0	10	8	1	22	0	17	0	8	0	6	0	11	0	5	0
6	0	0	1	17	0	4	0	2	5	5	2	0	0	0	4
22	33	30	2	42	32	4	0	16	5	11	0	0	0	0	2
22	74	80	34	83	178	120	60	48	72	77	76	37	0	2	0
17	41	5	18	70	70	8	0	5	5	15	0	0	0	0	0
22	11	5	1	34	20	8	0	12	5	11	0	0	0	5	0
17	33	5	0	34	17	5	0	8	0	6	0	0	0	5	0
17	33	27	1	25	0	2	0	5	0	6	0	0	0	5	0
22	33	6	1	32	0	5	0	4	0	0	0	8	0	4	0
22	11	5	1	42	20	5	0	17	34	2	0	17	0	5	0
22	10	0	2	28	0	5	0	11	0	11	0	0	0	5	0
2	0	5	1	52	41	5	0	8	2	2	0	8	0	4	0
17	82	72	33	74	156	36	29	34	17	11	0	0	0	6	0
17	33	30	20	65	121	127	58	40	42	38	48	17	0	0	8
2	0	0	2	0	4	0	8	0	5	5	0	0	0	0	1
22	10	6	1	34	0	12	0	4	14	2	8	0	0	4	0
2	13	0	12	29	0	2	0	17	5	11	0	0	0	11	40
22	74	56	1	22	0	20	0	8	0	2	0	8	0	2	0
2	0	6	5	29	0	8	0	8	5	11	0	0	0	6	0
22	33	5	5	32	26	8	0	8	5	11	0	14	0	5	0
17	11	6	29	62	67	48	60	53	61	67	54	5	4	0	5
6	0	8	15	8	5	0	1	0	2	0	0	0	0	4	0
22	33	5	1	23	0	2	0	4	14	2	0	8	0	4	0

	Cond.	P.Test	S.Test	K.Test	A.Test	O.Test	D.Test	F.Test1	F.Test2	F.Test3	F.Test4
1	NL	•	•	•	100	•	100	85	100	•	•
2	NL	100	100	100	100	100	100	91	100	100	•
3	NL	100	100	100	100	100	•	100	100	•	•
4	NL	100	100	•	100	50	•	92	100	•	•
5	NL	•	100	100	100	•	•	86	100	90	•
6	NL	100	100	•	100	100	•	93	•	•	•
7	NL	100	100	•	67	100	0	•	•	•	•
8	NL	100	100	100	67	•	100	90	•	•	•
9	NL	•	100	•	100	100	100	100	•	•	•
10	NL	•	•	•	100	100	•	100	89	100	80
11	NL	100	100	60	100	100	•	100	•	•	•
12	NL	100	100	100	100	•	100	81	•	•	•
13	NL	•	•	•	100	100	•	90	100	•	•
14	NL	100	100	80	100	100	100	100	85	•	•
15	NL	100	100	100	100	100	100	90	100	100	•
16	NL	100	100	•	100	100	•	100	100	•	•
17	NL	100	100	•	100	•	•	100	•	•	•
18	NL	100	100	100	100	100	•	100	92	•	•
19	NL	100	100	80	100	100	•	87	•	•	•
20	NL	100	100	100	100	100	100	94	•	•	•
21	L	100	100	100	100	100	100	90	100	100	•
22	L	100	100	80	100	100	100	58	•	•	•
23	L	100	100	100	100	100	100	64	100	•	•
24	L	100	100	100	100	100	100	100	•	•	•
25	L	100	100	60	100	100	100	96	•	•	•
26	L	100	100	100	100	100	100	92	100	•	•
27	L	100	100	100	100	100	100	70	81	•	•
28	L	100	100	100	100	100	0	97	•	•	•

Appendix 9.4. Practice Performance Data

	Cond.	P.Test	S.Test	K.Test	A.Test	O.Test	D.Test	F.Test1	F.Test2	F.Test3	F.Test4
30	L	100	100	100	100	100	100	81	•	•	•
31	L	100	100	100	100	100	100	95	100	•	•
32	L	100	100	100	100	100	100	100	•	•	•
33	L	100	100	100	100	100	100	100	•	•	•
34	L	100	100	100	66	100	100	87	•	•	•
35	L	100	100	100	100	100	100	100	•	•	•
36	L	100	66	100	100	100	100	100	•	•	•
37	L	100	100	100	100	100	100	100	•	•	•
38	L	100	66	80	100	100	100	81	100	•	•
39	L	100	100	80	100	100	100	92	100	•	•
40	L	100	100	80	100	100	100	75	•	•	•
41	SA	100	100	100	100	100	100	100	•	•	•
42	SA	100	100	100	100	100	100	86	•	•	•
43	SA	100	100	80	100	100	100	90	91	•	•
44	SA	100	100	100	100	100	100	100	•	•	•
45	SA	100	66	60	100	100	100	94	•	•	•
46	SA	100	100	100	100	100	100	88	100	•	•
47	SA	100	100	100	100	100	100	75	•	•	•
48	SA	100	100	100	66	100	100	100	•	•	•
49	SA	100	100	100	100	100	100	100	•	•	•
50	SA	100	100	80	100	100	100	100	•	•	•
51	SA	100	66	100	100	100	100	100	100	100	•
52	SA	100	100	80	100	100	100	85	•	•	•
53	SA	100	100	100	100	100	100	92	100	95	•
54	SA	100	100	80	100	100	100	100	•	•	•
55	SA	100	100	60	100	100	100	100	100	•	•
56	SA	100	100	100	100	100	100	100	•	•	•
57	SA	100	100	100	100	100	100	93	•	•	•

	Cond.	P.Test	S.Test	K.Test	A.Test	O.Test	D.Test	F.Test1	F.Test2	F.Test3	F.Test4
59	SA	100	100	60	100	100	0	78	•	•	•
60	SA	100	66	80	40	100	100	76	91	91	•

Appendix 9.4. Practice Performance Data

Unpaired t-Test X_1: Cond. Y_1: P.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	•	•

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	100	0	0
SA	20	100	0	0

1

Unpaired t-Test X_1: Cond. Y_2: S.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	.872	.3888

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	96.6	10.465	2.34
SA	20	93.2	13.953	3.12

2

Unpaired t-Test X_1: Cond. Y_3: K.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	1.177	.2466

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	94	11.425	2.555
SA	20	89	15.183	3.395

3

Unpaired t-Test X_1: Cond. Y_4: A.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	.795	.4316

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	98.3	7.603	1.7
SA	20	95.3	15.069	3.369

4

Unpaired t-Test X_1: Cond. Y_5: O.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	•	•

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	100	0	0
SA	20	100	0	0

5

Unpaired t-Test X_1: Cond. Y_6: D.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	0	•

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	95	22.361	5
SA	20	95	22.361	5

6

Unpaired t-Test X_1: Cond. Y_7: F.Test1

DF:	Unpaired t Value:	Prob. (2-tail):
38	-1.115	.2717

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	20	88.9	13.159	2.942
SA	20	92.85	8.816	1.971

7

Unpaired t-Test X_1: Cond. Y_8: F.Test2

DF:	Unpaired t Value:	Prob. (2-tail):
11	.083	.9351

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	7	97.286	7.181	2.714
SA	6	97	4.648	1.897

8

Unpaired t-Test X_1: Cond. Y_9: F.Test3

DF:	Unpaired t Value:	Prob. (2-tail):
2	.896	.4647

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
L	1	100	•	•
SA	3	95.333	4.509	2.603

9

A group contains no values. This statistic can not be computed for Column X(1)-Column Y(10).

10

Unpaired t-Test X_1: Cond. Y_1: P.Test

DF:	Unpaired t Value:	Prob. (2-tail):
33	•	•

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	15	100	0	0
L	20	100	0	0

1

Unpaired t-Test X_1: Cond. Y_2: S.Test

DF:	Unpaired t Value:	Prob. (2-tail):
35	1.337	.1899

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	17	100	0	0
L	20	96.6	10.465	2.34

2

Unpaired t-Test X_1: Cond. Y_3: K.Test

DF:	Unpaired t Value:	Prob. (2-tail):
29	-.278	.7826

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	11	92.727	13.484	4.066
L	20	94	11.425	2.555

3

Unpaired t-Test X_1: Cond. Y_4: A.Test

DF:	Unpaired t Value:	Prob. (2-tail):
38	-.564	.5761

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	20	96.7	10.157	2.271
L	20	98.3	7.603	1.7

4

Unpaired t-Test X_1: Cond. Y_5: O.Test

DF:	Unpaired t Value:	Prob. (2-tail):
33	-1.161	.2541

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	15	96.667	12.91	3.333
L	20	100	0	0

5

Unpaired t-Test X_1: Cond. Y_6: D.Test

DF:	Unpaired t Value:	Prob. (2-tail):
27	-.583	.5645

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	9	88.889	33.333	11.111
L	20	95	22.361	5

6

Unpaired t-Test X_1: Cond. Y_7: F.Test1

DF:	Unpaired t Value:	Prob. (2-tail):
37	1.42	.1639

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	19	93.632	6.282	1.441
L	20	88.9	13.159	2.942

7

Unpaired t-Test X_1: Cond. Y_8: F.Test2

DF:	Unpaired t Value:	Prob. (2-tail):
16	-.126	.9015

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	11	96.909	5.522	1.665
L	7	97.286	7.181	2.714

8

Unpaired t-Test X_1: Cond. Y_9: F.Test3

DF:	Unpaired t Value:	Prob. (2-tail):
3	-.447	.685

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
NL	4	97.5	5	2.5
L	1	100	•	•

9

A group contains no values. This statistic can not be computed for Column X(1)-Column Y(10).

10

Appendix 10. Non-Linear Data

Comparison of the three methods of grouping subjects in the non-linear condition.

SUBJECT	Embedded Figures	Observed Strategy	Reported Strategy
6	FI	TD	TD
8	FI/FD	E	S
11	FI/FD	S	S
14	FI/FD	S	BU
17	FI/FD	S	BU
20	FD	E	S
23	FI/FD	TD	TD
26	FD	S	BU
32	FI	TD	TD
33	FD	TD	TD
35	FI	S	S
36	FD	S	BU
41	FI/FD	TD	TD
42	FD	E	BU
49	FI	E	BU
51	FI	S	S
55	FI/FD	S	S
57	FI	E	S
61	FI/FD	TD	TD
66	FD	S	S

Appendix 10.1. Comparison of Grouping Methods

	Group	EFT	Mod. Compl.	Repeats	Not Done	Training time	Mod/Time
1	Top Do...	13.25	9	1	6	2156.38	239.60
2	Top Do...	24.33	13	1	2	2730.35	210.03
3	Top Do...	15.50	10	0	4	1864.27	186.43
4	Top Do...	43.08	13	5	6	2356.90	181.30
5	Top Do...	23.33	12	3	4	2415.80	210.32
6	Top Do...	26.92	13	0	2	3193.38	245.64
7	Botto...	20.42	15	1	0	2734.07	182.27
8	Botto...	27.08	14	3	3	3289.62	234.97
9	Botto...	57.17	15	1	0	2935.37	195.69
10	Botto...	49.75	14	0	0	3464.08	247.43
11	Botto...	37.50	17	3	0	3090.17	181.77
12	Botto...	13.17	14	2	2	2521.53	180.12
13	Seque...	20.25	17	3	0	2533.77	149.05
14	Seque...	29.25	13	1	2	2890.75	222.37
15	Seque...	33.08	15	2	2	2080.22	138.68
16	Seque...	14.92	13	0	1	2931.17	225.47
17	Seque...	11.50	15	3	2	2587.58	172.51
18	Seque...	24.25	10	1	4	1853.13	185.31
19	Seque...	10.58	22	10	1	3325.42	151.16
20	Seque...	32.08	14	0	1	2917.82	208.42

Appendix 10.2. Reported Strategy Data

	Task output
1	772
2	1785
3	1586
4	1477
5	2216
6	1130
7	1270
8	1819
9	1949
10	2270
11	2680
12	2651
13	1419
14	4995
15	1141
16	2203
17	1549
18	1252
19	1690
20	2759

One Factor ANOVA X_1: Group Y_1: EFT

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	542.942	271.471	1.776
Within groups	17	2598.982	152.881	p = .1994
Total	19	3141.924		

Model II estimate of between component variance = 59.295

1

One Factor ANOVA X_1: Group Y_1: EFT

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	24.402	10.583	4.32
Bottom Up	6	34.182	17.106	6.984
Sequential	8	21.989	9.07	3.207

2

One Factor ANOVA X_1: Group Y_1: EFT

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Bottom Up	-9.78	15.063	.938	1.37
Top Down vs. Sequential	2.413	14.09	.065	.361
Bottom Up vs. Sequential	12.193	14.09	1.667	1.826

3

Appendix 10.2.1. Parametric Analyses

One Factor ANOVA X_1: Group Y_2: Training time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	955609.709	477804.855	2.445
Within groups	17	3322489.344	195440.55	p = .1166
Total	19	4278099.053		

Model II estimate of between component variance = 141182.153

4

One Factor ANOVA X_1: Group Y_2: Training time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	2452.847	462.664	188.882
Bottom Up	6	3005.807	349.573	142.713
Sequential	8	2639.982	484.206	171.193

5

One Factor ANOVA X_1: Group Y_2: Training time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Bottom Up	-552.96	538.566*	2.347	2.166
Top Down vs. Sequential	-187.136	503.782	.307	.784
Bottom Up vs. Sequential	365.824	503.782	1.174	1.532

* Significant at 95%

6

One Factor ANOVA X_1: Group Y_3: Mod/Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	3548.302	1774.151	1.864
Within groups	17	16177.302	951.606	p = .1853
Total	19	19725.604		

Model II estimate of between component variance = 411.272

7

One Factor ANOVA X_1: Group Y_3: Mod/Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	212.22	26.443	10.795
Bottom Up	6	203.708	29.834	12.18
Sequential	8	181.621	34.29	12.123

8

One Factor ANOVA X_1: Group Y_3: Mod/Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Bottom Up	8.512	37.58	.114	.478
Top Down vs. Sequential	30.599	35.153	1.687	1.837
Bottom Up vs. Sequential	22.087	35.153	.879	1.326

9

One Factor ANOVA X_1: Group Y_4: Task Output

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	1633065.717	816532.858	.983
Within groups	17	14122560.833	830738.873	p = .3945
Total	19	15755626.55		

Model II estimate of between component variance = -7103.007

10

One Factor ANOVA X_1: Group Y_4: Task Output

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	1494.333	503.686	205.629
Bottom Up	6	2106.5	540.242	220.553
Sequential	8	2126	1275.861	451.085

11

One Factor ANOVA X_1: Group Y_4: Task Output

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Bottom Up	-612.167	1110.359	.677	1.163
Top Down vs. Sequential	-631.667	1038.646	.823	1.283
Bottom Up vs. Sequential	-19.5	1038.646	.001	.04

12

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
Top Down	6	21	3.5
Bottom Up	6	57	9.5

U	0
U-prime	36
Z	-2.882
Z corrected for ties	-2.929
# tied groups	3

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
Top Down	6	37	6.167
Bottom Up	6	41	6.833

U	16
U-prime	20
Z	-.32
Z corrected for ties	-.331
# tied groups	3

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
Top Down	6	54	9
Bottom Up	6	24	4

U	3
U-prime	33
Z	-2.402
Z corrected for ties	-2.472
# tied groups	4

3

Appendix 10.2.2. Non-Parametric Analyses

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
Top Down	6	28.5	4.75
Sequential	8	76.5	9.562

U	7.5
U-prime	40.5
Z	-2.13
Z corrected for ties	-2.184
# tied groups	3

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
Top Down	6	42	7
Sequential	8	63	7.875

U	21
U-prime	27
Z	-.387
Z corrected for ties	-.398
# tied groups	3

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
Top Down	6	63	10.5
Sequential	8	42	5.25

U	6
U-prime	42
Z	-2.324
Z corrected for ties	-2.402
# tied groups	4

3

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
m Up	6	48	8
ential	8	57	7.125

U	21
U-prime	27
Z	-.387
Z corrected for ties	-.397
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
m Up	6	44.5	7.417
ential	8	60.5	7.562

U	23.5
U-prime	24.5
Z	-.065
Z corrected for ties	-.066
# tied groups	4

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
n Up	6	35.5	5.917
ntial	8	69.5	8.688

U	14.5
U-prime	33.5
Z	-1.226
Z corrected for ties	-1.275
# tied groups	3

3

	Group	EFT	Mod. Compl.	Repeats	Not Done	Training time	Mod/Time
1	FI	10.58	22	10	1	3325.42	151.16
2	FI	11.50	15	3	2	2587.58	172.51
3	FI	13.17	14	2	2	2521.53	180.12
4	FI	13.25	9	1	6	2156.38	239.60
5	FI	14.92	13	0	1	2931.17	225.47
6	FI	15.50	10	0	4	1864.27	186.43
7	FI/FD	20.25	17	3	0	2533.77	149.05
8	FI/FD	20.42	15	1	0	2734.07	182.27
9	FI/FD	23.33	12	3	4	2415.80	201.32
10	FI/FD	24.25	10	1	4	1853.13	185.31
11	FI/FD	24.33	13	1	2	2730.35	210.03
12	FI/FD	26.92	13	0	2	3193.38	245.64
13	FI/FD	27.08	14	3	3	3289.62	234.97
14	FI/FD	29.25	13	1	2	2890.75	222.37
15	FD	32.08	14	0	1	2917.82	208.42
16	FD	33.08	15	2	2	2080.22	135.68
17	FD	37.50	17	3	0	3090.17	181.77
18	FD	43.08	13	5	6	2359.90	181.30
19	FD	49.75	14	0	0	3464.08	245.43
20	FD	57.17	15	1	0	2935.37	195.69

Appendix 10.3. Embedded Figures Test Data

	Task Output
1	1690
2	1539
3	2651
4	772
5	2203
6	1587
7	1419
8	1270
9	2216
10	1252
11	1785
12	1130
13	1819
14	4995
15	2759
16	1141
17	2680
18	1477
19	2270
20	1949

One Factor ANOVA X_1: Group Y_1: EFT

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	2563.182	1281.591	37.646
Within groups	17	578.742	34.044	p = .0001
Total	19	3141.924		

Model II estimate of between component variance = 623.774

1

One Factor ANOVA X_1: Group Y_1: EFT

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
FI	6	13.153	1.897	.774
FI/FD	8	24.479	3.19	1.128
FD	6	42.11	9.895	4.039

2

One Factor ANOVA X_1: Group Y_1: EFT

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
FI vs. FI/FD	-11.325	6.649*	6.459*	3.594
FI vs. FD	-28.957	7.108*	36.945*	8.596
FI/FD vs. FD	-17.631	6.649*	15.654*	5.595

* Significant at 95%

3

One Factor ANOVA X_1: Group Y_2: Training time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	179651.505	89825.752	.373
Within groups	17	4096435.964	240966.821	p = .6943
Total	19	4276087.469		

Model II estimate of between component variance = -75570.534

4

One Factor ANOVA X_1: Group Y_2: Training time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
FI	6	2564.392	523.967	213.909
FI/FD	8	2705.109	455.902	161.186
FD	6	2807.927	503.746	205.654

5

One Factor ANOVA X_1: Group Y_2: Training time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
FI vs. FI/FD	-140.717	559.389	.141	.531
FI vs. FD	-243.535	598.012	.369	.859
FI/FD vs. FD	-102.818	559.389	.075	.388

6

One Factor ANOVA X_1: Group Y_3: Mod/Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	684.383	342.191	.305
Within groups	17	19045.818	1120.342	p = .7408
Total	19	19730.2		

Model II estimate of between component variance = -389.075

7

One Factor ANOVA X_1: Group Y_3: Mod/Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
FI	6	192.548	33.479	13.668
FI/FD	8	203.87	31.43	11.112
FD	6	191.382	36.13	14.75

8

One Factor ANOVA X_1: Group Y_3: Mod/Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
FI vs. FI/FD	-11.322	38.143	.196	.626
FI vs. FD	1.167	40.776	.002	.06
FI/FD vs. FD	12.488	38.143	.239	.691

9

One Factor ANOVA X_1: Group Y_4: Task Output

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	321440.367	160720.183	.177
Within groups	17	15441226.833	908307.461	p = .8393
Total	19	15762667.2		

Model II estimate of between component variance = -373793.639

10

One Factor ANOVA X_1: Group Y_4: Task Output

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
FI	6	1740.333	639.941	261.255
FI/FD	8	1985.75	1269.472	448.826
FD	6	2046	650.03	265.374

11

One Factor ANOVA X_1: Group Y_4: Task Output

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
FI vs. FI/FD	-245.417	1086.055	.114	.477
FI vs. FD	-305.667	1161.041	.154	.556
FI/FD vs. FD	-60.25	1086.055	.007	.117

12

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
FI	6	45	7.5
FI/FD	8	60	7.5

U	24
U-prime	24
Z	0
Z corrected for ties	0
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
FI	6	44.5	7.417
FI/FD	8	60.5	7.562

U	23.5
U-prime	24.5
Z	-.065
Z corrected for ties	-.067
# tied groups	3

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
FI	6	47	7.833
FI/FD	8	58	7.25

U	22
U-prime	26
Z	-.258
Z corrected for ties	-.266
# tied groups	4

3

Appendix 10.3.2. Non-Parametric Analyses

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
FI	6	33.5	5.583
FD	6	44.5	7.417

U	12.5
U-prime	23.5
Z	-.881
Z corrected for ties	-.895
# tied groups	3

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
FI	6	39.5	6.583
FD	6	38.5	6.417

U	17.5
U-prime	18.5
Z	-.08
Z corrected for ties	-.082
# tied groups	4

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
FI	6	47.5	7.917
FD	6	30.5	5.083

U	9.5
U-prime	26.5
Z	-1.361
Z corrected for ties	-1.393
# tied groups	4

3

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	∑ Rank:	Mean Rank:
FI/FD	8	49	6.125
FD	6	56	9.333

U	13
U-prime	35
Z	-1.42
Z corrected for ties	-1.451
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	∑ Rank:	Mean Rank:
FI/FD	8	60.5	7.562
FD	6	44.5	7.417

U	23.5
U-prime	24.5
Z	-.065
Z corrected for ties	-.067
# tied groups	3

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	∑ Rank:	Mean Rank:
FI/FD	8	67.5	8.438
FD	6	37.5	6.25

U	16.5
U-prime	31.5
Z	-.968
Z corrected for ties	-1.003
# tied groups	3

3

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
FI/FD	8	49	6.125
FD	6	56	9.333

U	13
U-prime	35
Z	-1.42
Z corrected for ties	-1.451
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
FI/FD	8	60.5	7.562
FD	6	44.5	7.417

U	23.5
U-prime	24.5
Z	-.065
Z corrected for ties	-.067
# tied groups	3

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
FI/FD	8	67.5	8.438
FD	6	37.5	6.25

U	16.5
U-prime	31.5
Z	-.968
Z corrected for ties	-1.003
# tied groups	3

3

	Group	EFT	Mod. Compl.	Repeats	Not Done	Training time	Mod/Time	Task Output
1	Top Do…	13.25	9	1	6	2156.38	239.60	772
2	Top Do…	24.33	13	1	2	2730.35	210.03	1785
3	Top Do…	15.50	10	0	4	1864.27	186.43	1586
4	Top Do…	43.08	13	5	6	2356.90	181.30	1477
5	Top Do…	23.33	12	3	4	2415.80	210.32	2216
6	Top Do…	26.92	13	0	2	3193.38	245.64	1130
7	Seque…	20.42	15	1	0	2734.07	182.27	1270
8	Seque…	29.25	13	1	2	2890.75	222.37	4995
9	Seque…	27.08	14	3	3	3289.62	234.97	1819
10	Seque…	57.17	15	1	0	2935.37	195.69	1949
11	Seque…	14.92	13	0	1	2931.17	225.47	2203
12	Seque…	49.75	14	0	0	3464.08	247.43	2270
13	Seque…	11.50	15	3	2	2587.58	172.51	1549
14	Seque…	24.25	10	1	4	1853.13	185.31	1252
15	Seque…	32.08	14	0	1	2917.82	208.42	2759
16	Elabor…	37.50	17	3	0	3090.17	181.77	2680
17	Elabor…	13.17	14	2	2	2521.53	180.12	2651
18	Elabor…	20.25	17	3	0	2890.75	149.05	4995
19	Elabor…	33.08	15	2	2	2080.22	138.68	1141
20	Elabor…	10.58	22	10	1	3325.42	151.16	1690

Appendix 10.4. Observed Strategy Data

	Retention
1	702.00
2	1865.00
3	896.00
4	952.00
5	1108.00
6	745.00
7	599.00
8	717.00
9	865.00
10	878.00
11	2150.00
12	901.00
13	810.00
14	847.00
15	888.00
16	1272.00
17	815.00
18	1460.00
19	1415.00
20	1169.00

One Factor ANOVA X_1: Group Y_1: EFT

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	176.922	88.461	.507
Within groups	17	2965.002	174.412	p = .611
Total	19	3141.924		

Model II estimate of between component variance = -42.975

1

One Factor ANOVA X_1: Group Y_1: EFT

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	24.402	10.583	4.32
Sequential	9	29.602	15.144	5.048
Elaborative	5	22.916	11.94	5.34

2

One Factor ANOVA X_1: Group Y_1: EFT

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Sequential	-5.201	14.687	.279	.747
Top Down vs. Elaborative	1.486	16.874	.017	.186
Sequential vs. Elaborative	6.686	15.543	.412	.908

3

Appendix 10.4.1. Parametric Analyses

One Factor ANOVA X_1: Group Y_2: Training time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	586015.875	293007.937	1.347
Within groups	17	3699041.789	217590.693	p = .2865
Total	19	4285057.664		

Model II estimate of between component variance = 37708.622

4

One Factor ANOVA X_1: Group Y_2: Training time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	2452.847	462.664	188.882
Sequential	9	2844.843	456.387	152.129
Elaborative	5	2781.618	490.52	219.367

5

One Factor ANOVA X_1: Group Y_2: Training time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Sequential	-391.997	518.753	1.271	1.594
Top Down vs. Elaborative	-328.771	.596.002	.677	1.164
Sequential vs. Elaborative	63.225	548.997	.03	.243

6

One Factor ANOVA X$_1$: Group Y$_3$: Mod/Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	9316.987	4658.494	7.609
Within groups	17	10408.617	612.272	p = .0044
Total	19	19725.604		

Model II estimate of between component variance = 2023.111

7

One Factor ANOVA X$_1$: Group Y$_3$: Mod/Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	212.22	26.443	10.795
Sequential	9	208.271	25.936	8.645
Elaborative	5	160.156	19.565	8.75

8

One Factor ANOVA X$_1$: Group Y$_3$: Mod/Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Sequential	3.949	27.518	.046	.303
Top Down vs. Elaborative	52.064	31.615*	6.037*	3.475
Sequential vs. Elaborative	48.115	29.122*	6.077*	3.486

* Significant at 95%

9

One Factor ANOVA X_1: Group Y_4: Task Output

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	3762198.194	1881099.097	1.561
Within groups	17	20482494.756	1204852.633	p = .2385
Total	19	24244692.95		

Model II estimate of between component variance = 338123.232

10

One Factor ANOVA X_1: Group Y_4: Task Output

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	1494.333	503.686	205.629
Sequential	9	2229.556	1146.578	382.193
Elaborative	5	2631.4	1474.523	659.427

11

One Factor ANOVA X_1: Group Y_4: Task Output

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Sequential	-735.222	1220.696	.808	1.271
Top Down vs. Elaborative	-1137.067	1402.473	1.463	1.711
Sequential vs. Elaborative	-401.844	1291.863	.215	.656

12

One Factor ANOVA X_1: Group Y_5: Retention

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	2	225482.067	112741.033	.674
Within groups	17	2844758.133	167338.714	p = .5229
Total	19	3070240.2		

Model II estimate of between component variance = -27298.84

13

One Factor ANOVA X_1: Group Y_5: Retention

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Top Down	6	1044.667	427.754	174.63
Sequential	9	961.667	456.225	152.075
Elaborative	5	1226.2	257.276	115.057

14

One Factor ANOVA X_1: Group Y_5: Retention

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Top Down vs. Sequential	83	454.924	.074	.385
Top Down vs. Elaborative	-181.533	522.668	.269	.733
Sequential vs. Elaborative	-264.533	481.446	.672	1.159

15

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
Top Down	6	28.5	4.75
Sequential	9	91.5	10.167

U	7.5
U-prime	46.5
Z	-2.298
Z corrected for ties	-2.36
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
Top Down	6	51	8.5
Sequential	9	69	7.667

U	24
U-prime	30
Z	-.354
Z corrected for ties	-.374
# tied groups	3

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
Top Down	6	68	11.333
Sequential	9	52	5.778

U	7
U-prime	47
Z	-2.357
Z corrected for ties	-2.4
# tied groups	5

3

Appendix 10.4.2. Non-Parametric Analyses

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
Top Down	6	21	3.5
Elaborative	5	45	9

U	0
U-prime	30
Z	-2.739
Z corrected for ties	-2.77
# tied groups	2

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
Top Down	6	28	4.667
Elaborative	5	38	7.6

U	7
U-prime	23
Z	-1.461
Z corrected for ties	-1.484
# tied groups	4

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
Top Down	6	49	8.167
Elaborative	5	17	3.4

U	2
U-prime	28
Z	-2.373
Z corrected for ties	-2.447
# tied groups	4

3

Mann-Whitney U X_1: Group Y_1: Mod. Compl.

	Number:	Σ Rank:	Mean Rank:
Sequential	9	51	5.667
Elaborative	5	54	10.8

U	6
U-prime	39
Z	-2.2
Z corrected for ties	-2.255
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	Σ Rank:	Mean Rank:
Sequential	9	51	5.667
Elaborative	5	54	10.8

U	6
U-prime	39
Z	-2.2
Z corrected for ties	-2.263
# tied groups	4

2

Mann-Whitney U X_1: Group Y_3: Not Done

	Number:	Σ Rank:	Mean Rank:
Sequential	9	71	7.889
Elaborative	5	34	6.8

U	19
U-prime	26
Z	-.467
Z corrected for ties	-.485
# tied groups	3

3

Appendix 11. Self Assessment & Non-SA Data

	Group	Mod Compl.	Repeats	Not Done	Train Time	Mod/Time	Transfer	Retention
1	Non-SA	17	2	0	2899.33	170.55	15497.00	5066.00
2	Non-SA	15	0	0	2465.58	164.37	4348.00	5612.00
3	Non-SA	16	1	0	2802.98	175.19	2290.00	1868.00
4	Non-SA	15	0	0	2171.63	144.78	2498.00	1572.00
5	Non-SA	15	0	0	2877.25	191.82	2167.00	995.00
6	Non-SA	16	1	0	2490.88	155.68	2232.00	1684.00
7	Non-SA	16	1	0	2729.57	170.60	3480.00	3503.00
8	Non-SA	15	0	0	2743.63	182.91	1542.00	1167.00
9	Non-SA	15	0	0	2043.52	136.23	1927.00	1023.00
10	Non-SA	15	0	0	1932.72	128.85	8544.00	1163.00
11	Non-SA	16	1	0	2784.93	174.06	9996.00	1323.00
12	Non-SA	15	0	0	2104.27	140.28	568.00	632.00
13	Non-SA	15	0	0	1909.22	127.28	1935.00	1265.00
14	Non-SA	15	0	0	3025.78	201.72	2619.00	1192.00
15	Non-SA	15	0	0	2105.53	140.37	3218.00	1227.00
16	Non-SA	15	0	0	2655.55	177.04	1791.00	1016.00
17	Non-SA	15	0	0	2188.98	145.93	2706.00	1681.00
18	Non-SA	16	1	0	2647.12	165.44	10418.00	1317.00
19	Non-SA	16	1	0	1830.00	114.38	931.00	703.00
20	Non-SA	15	0	0	3005.28	200.35	2835.00	988.00
21	SA	15	0	0	2130.58	142.04	9953.00	1700.00
22	SA	15	0	0	2062.23	137.48	1696.00	3649.00
23	SA	16	1	0	2825.67	176.60	2993.00	1766.00
24	SA	15	0	0	2308.72	153.91	3239.00	849.00
25	SA	15	0	0	2644.98	176.33	1229.00	1185.00
26	SA	16	1	0	2271.67	141.98	1947.00	1161.00
27	SA	15	0	0	2744.12	182.94	966.00	821.00
28	SA	15	0	0	2426.38	161.76	642.00	604.00
29	SA	15	0	0	2210.58	147.37	1929.00	894.00

	Group	Mod Compl.	Repeats	Not Done	Train Time	Mod/Time	Transfer	Retention
30	SA	15	0	0	2200.08	146.67	1774.00	645.00
31	SA	17	2	0	3844.70	226.16	3589.00	2324.00
32	SA	15	0	0	2859.12	190.61	3617.00	1128.00
33	SA	18	3	0	5997.92	333.22	2941.00	2728.00
34	SA	15	0	0	2370.12	158.01	1889.00	1875.00
35	SA	16	1	0	2339.58	146.22	1790.00	930.00
36	SA	15	0	0	2185.60	145.71	2046.00	1036.00
37	SA	15	0	0	2537.03	169.14	1651.00	683.00
38	SA	15	0	0	2798.90	186.59	1417.00	1215.00
39	SA	15	0	0	4514.92	300.99	1764.00	1560.00
40	SA	18	3	0	3019.30	167.74	3544.00	757.00

One Factor ANOVA X_1: Group Y_1: Train Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	1182826.86	1182826.86	2.189
Within groups	38	20530794.443	540284.064	p = .1472
Total	39	21713621.303		

Model II estimate of between component variance = 642542.796

1

One Factor ANOVA X_1: Group Y_1: Train Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Non-SA	20	2814.61	960.741	214.828
SA	20	2470.688	396.92	88.754

2

One Factor ANOVA X_1: Group Y_1: Train Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Non-SA vs. SA	343.922	470.599	2.189	1.48

3

Appendix 11.1. Parametric Analyses

One Factor ANOVA X_1: Group Y_2: Mod/Time

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	3679.868	3679.868	2.213
Within groups	38	63187.354	1662.825	p = .1451
Total	39	66867.223		

Model II estimate of between component variance = 2017.043

4

One Factor ANOVA X_1: Group Y_2: Mod/Time

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Non-SA	20	179.574	52.004	11.628
SA	20	160.391	24.925	5.573

5

One Factor ANOVA X_1: Group Y_2: Mod/Time

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Non-SA vs. SA	19.183	26.107	2.213	1.488

6

One Factor ANOVA X_1: Group Y_3: Transfer

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	23910436.9	23910436.9	2.517
Within groups	38	360921307	9497929.132	p = .1209
Total	39	384831743.9		

Model II estimate of between component variance = 14412507.768

7

One Factor ANOVA X_1: Group Y_3: Transfer

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Non-SA	20	2530.8	1957.179	437.639
SA	20	4077.1	3894.266	870.784

8

One Factor ANOVA X_1: Group Y_3: Transfer

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Non-SA vs. SA	-1546.3	1973.123	2.517	1.587

9

One Factor ANOVA X_1: Group Y_4: Retention

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	1401379.225	1401379.225	1.128
Within groups	38	47206659.55	1242280.514	p = .2949
Total	39	48608038.775		

Model II estimate of between component variance = 159098.711

10

One Factor ANOVA X_1: Group Y_4: Retention

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
Non-SA	20	1375.5	785.713	175.691
SA	20	1749.85	1366.461	305.55

11

One Factor ANOVA X_1: Group Y_4: Retention

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
Non-SA vs. SA	-374.35	713.591	1.128	1.062

12

Anova table for a 2-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Group (A)	1	18444482.112	18444482.112	2.735	.1064
subjects w. groups	38	256292596.575	6744542.015		
Repeated Measure (B)	1	60640772.513	60640772.513	15.177	.0004
AB	1	6867334.013	6867334.013	1.719	.1977
B x subjects w. groups	38	151835369.975	3995667.631		

There were no missing cells found.

1

The AB Incidence table

Group	Repeated Mea...	Transfer	Retention	Totals:
Group	SA	20 2530.8	20 1375.5	40 1953.15
Group	Non-SA	20 4077.1	20 1749.85	40 2913.475
	Totals:	40 3303.95	40 1562.675	80 2433.312

2

Mann-Whitney U X_1: Group Y_1: Mod Compl.

	Number:	$\sum$ Rank:	Mean Rank:
Non-SA	20	408.5	20.425
SA	20	411.5	20.575

U	198.5
U-prime	201.5
Z	-.041
Z corrected for ties	-.049
# tied groups	4

1

Mann-Whitney U X_1: Group Y_2: Repeats

	Number:	$\sum$ Rank:	Mean Rank:
Non-SA	20	408.5	20.425
SA	20	411.5	20.575

U	198.5
U-prime	201.5
Z	-.041
Z corrected for ties	-.049
# tied groups	4

2

ANOVA Summary Table for Nev 4 (M.Phil.):DATA:SA_Data:TvsNQ(points)

Source of Variation	df	Sum of Squares	Mean Square	F	p	Epsilon Correction
G	1	4821.620	4821.620	2.229	.1437	
Error	38	82188.175	2162.847			
T	19	60793.945	3199.681	15.618	.0000	
GT	19	5273.530	277.554	1.355	.1421	
Error	722	147917.325	204.872			.16

<u>Appendix 11.3. Transfer Performance Data</u>

ffect	MSn	DFn	DFe	MSe	F	p
; at T 1	3.600	1	38	73.379	.049	.826
; at T 2	240.100	1	38	584.639	.411	.525
; at T 3	78.400	1	38	520.211	.151	.700
; at T 4	119.025	1	38	95.546	1.246	.271
; at T 5	1440.000	1	38	461.463	3.121	.085
; at T 6	4622.500	1	38	1727.461	2.676	.110
; at T 7	940.900	1	38	800.763	1.175	.285
; at T 8	366.025	1	38	343.393	1.066	.308
; at T 9	409.600	1	38	183.274	2.235	.143
; at T 10	570.025	1	38	373.509	1.526	.224
; at T 11	874.225	1	38	280.199	3.120	.085
; at T 12	220.900	1	38	347.921	.635	.431
; at T 13	70.225	1	38	86.230	.814	.373
; at T 14	.625	1	38	1.372	.455	.504
; at T 15	.225	1	38	10.757	.021	.886
; at T 16	21.025	1	38	45.314	.464	.500
; at T 17	25.600	1	38	25.284	1.012	.321
; at T 18	27.225	1	38	17.409	1.564	.219
; at T 19	4.900	1	38	20.553	.238	.628
; at T 20	60.025	1	38	56.730	1.058	.310
at G 1	1082.276	19	722	204.872	5.283	.000
at G 2	2394.959	19	722	204.872	11.690	.000

	Group	Gen. Conf.	Pub. Speak	Athlet.	Social Conf.	Appear.	I.Q.	Mood	Person. W.
1	Non-SA	14	27	21	20	22	20	17	27
2	Non-SA	31	29	17	26	24	33	22	26
3	Non-SA	28	25	19	20	28	31	26	24
4	Non-SA	17	19	19	22	31	26	21	23
5	Non-SA	27	23	12	21	27	27	26	26
6	Non-SA	25	26	18	20	21	18	24	30
7	Non-SA	26	25	21	25	19	34	22	24
8	Non-SA	24	24	16	24	27	30	23	27
9	Non-SA	28	22	19	30	32	34	25	27
10	Non-SA	18	20	16	21	24	23	23	30
11	Non-SA	27	21	15	23	25	30	23	29
12	Non-SA	38	27	21	25	35	37	21	31
13	Non-SA	24	24	15	24	31	27	31	30
14	Non-SA	23	24	13	25	32	33	27	27
15	Non-SA	15	18	15	23	29	17	21	26
16	Non-SA	34	27	13	25	22	35	20	26
17	Non-SA	32	24	13	29	27	33	30	30
18	Non-SA	30	20	20	20	27	30	25	28
19	Non-SA	32	25	20	23	29	32	25	31
20	Non-SA	31	25	18	24	29	28	23	26
21	SA	26	19	12	23	19	31	19	27
22	SA	29	25	18	25	31	27	28	29
23	SA	30	26	21	18	25	34	29	30
24	SA	26	26	19	23	25	29	23	24
25	SA	20	21	18	21	31	27	25	29
26	SA	19	22	15	25	27	26	22	33
27	SA	34	29	20	29	33	36	19	3
28	SA	26	27	15	26	27	27	25	28
29	SA	34	26	21	23	30	36	24	28

Appendix 11.4. Self Confidence Questionnaire Data

	Group	Gen. Conf.	Pub. Speak	Athlet.	Social Conf.	Appear.	I.Q.	Mood	Person. W.
30	SA	31	27	15	26	27	36	27	27
31	SA	34	32	20	26	30	31	22	31
32	SA	37	30	21	27	32	28	24	31
33	SA	24	27	15	21	28	29	20	25
34	SA	24	23	14	22	29	29	29	30
35	SA	28	23	17	23	23	20	25	27
36	SA	29	27	20	26	27	30	22	31
37	SA	35	27	18	22	33	37	24	29
38	SA	30	27	19	24	25	35	25	31
39	SA	19	21	13	23	21	32	26	23
40	SA	28	16	20	22	26	39	28	29

Mann-Whitney U X_1: Group Y_1: Gen. Conf.

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	375	18.75
SA	20	445	22.25

U	165
U-prime	235
Z	-.947
Z corrected for ties	-.949
# tied groups	10

1

Mann-Whitney U X_1: Group Y_2: Pub. Speak

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	357	17.85
SA	20	463	23.15

U	147
U-prime	253
Z	-1.434
Z corrected for ties	-1.445
# tied groups	10

2

Mann-Whitney U X_1: Group Y_3: Athlet.

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	392	19.6
SA	20	428	21.4

U	182
U-prime	218
Z	-.487
Z corrected for ties	-.491
# tied groups	9

3

Appendix 11.5. Self Confidence Questionnaire Analyses

Mann-Whitney U X_1: Group Y_4: Social Conf.

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	390	19.5
SA	20	430	21.5

U	180
U-prime	220
Z	-.541
Z corrected for ties	-.546
# tied groups	8

4

Mann-Whitney U X_1: Group Y_5: Appear.

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	398.5	19.925
SA	20	421.5	21.075

U	188.5
U-prime	211.5
Z	-.311
Z corrected for ties	-.313
# tied groups	12

5

Mann-Whitney U X_1: Group Y_6: I.Q.

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	376.5	18.825
SA	20	443.5	22.175

U	166.5
U-prime	233.5
Z	-.906
Z corrected for ties	-.909
# tied groups	13

6

Mann-Whitney U X_1: Group Y_7: Mood

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	385.5	19.275
SA	20	434.5	21.725

U	175.5
U-prime	224.5
Z	-.663
Z corrected for ties	-.666
# tied groups	11

7

Mann-Whitney U X_1: Group Y_8: Person. W.

	Number:	Σ Rank:	Mean Rank:
Non-SA	20	367.5	18.375
SA	20	452.5	22.625

U	157.5
U-prime	242.5
Z	-1.15
Z corrected for ties	-1.159
# tied groups	8

8

	P1	P2	S1	S2	S3	K1	K2	K3	K4	K5	A1	01	D1	F1	F2	F3	F4
1	4	4	3	3	3	4	4	4	4	4	4	4	5	4	•	•	•
2	0	0	0	0	3	3	0	5	5	5	5	5	5	5	•	•	•
3	4	4	5	5	5	5	4	5	4	5	4	5	5	4	4	•	•
4	5	5	5	5	3	5	4	3	5	5	4	5	5	4	•	•	•
5	4	5	5	3	5	5	5	5	4	5	5	5	5	5	•	•	•
6	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	•	•
7	5	5	5	5	5	5	5	5	3	5	5	5	5	5	•	•	•
8	5	5	5	5	5	5	5	4	5	5	5	5	5	5	•	•	•
9	5	4	5	5	5	5	5	5	5	4	5	5	5	5	•	•	•
10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	•	•	•
11	4	5	5	4	4	5	5	5	5	3	4	5	5	5	5	5	•
12	4	5	5	5	5	5	5	5	4	3	5	5	5	5	•	•	•
13	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	•
14	5	5	5	5	5	5	5	3	4	5	5	5	5	5	•	•	•
15	0	5	5	5	5	0	5	5	5	5	5	5	5	5	5	•	•
16	4	4	0	4	5	4	4	4	4	4	4	4	4	4	•	•	•
17	4	4	5	5	5	3	4	5	5	3	4	5	5	5	•	•	•
18	4	4	4	4	4	4	4	4	4	3	4	4	4	4	•	•	•
19	0	5	5	5	5	5	5	3	3	5	5	5	0	5	•	•	•
20	5	5	5	5	5	5	5	5	5	4	5	5	5	0	2	5	4

Appendix 11.6. Self Assessment Data

Friedman 14 X variables

DF	13
# Samples	14
# Cases	20
Chi_r-Squared	9.179
Chi corrected for ties	20.146
# tied groups	36

1

Friedman 14 X variables

Name:	∑ Rank:	Mean Rank:
P1	115	5.75
P2	149.5	7.475
S1	156.5	7.825
S2	148.5	7.425
S3	151	7.55

2

Friedman 14 X variables

Name:	∑ Rank:	Mean Rank:
K1	150	7.5
K2	150.5	7.525
K3	148.5	7.425
K4	138	6.9
K5	131	6.55

3

Friedman 14 X variables

Name:	∑ Rank:	Mean Rank:
A1	152	7.6
O1	177.5	8.875
D1	175	8.75
F1	157	7.85

4

Appendix 11.7. Self Assessment Analyses